# THE INSTITUTE OF PHYSICS BULLETIN

VOLUME 11 . NUMBER 12 . DECEMBER, 1960

CONTENTS

Selection for University Education G. K. T. Conn 321
Notes and News . . . . . 326
The Requirements of Industry for Physicists M. Milbourn 327
The Diploma in Advanced Studies in Physics at Manchester University . . J. B. Birks 333
National Certificates in Applied Physics: 1960 Examinations . . . . . 335
News of Members . . . . . 337
Appeal for the Physics Trust Fund . . . 338
Reviews of Books . . . . . 339
Forthcoming Institute and Society Meetings . 346
The Journals . . . . . 347
Papers accepted for publication in *Proceedings of The Physical Society* . . . . . 349
Index to Volume 11 . . . . . 352

*Published by The Institute of Physics and The Physical Society*

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*The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.*

ROYAL TECHNICAL COLLEGE, SALFORD

A vacancy exists for a READER in the DEPARTMENT OF ELECTRICAL ENGINEERING. This is primarily a research appointment suitable for an electrical engineer or physicist. The successful applicant will be expected to direct research in the department. Some years leading a team in research, or in supervising the research of Ph.D. students, would be a strong recommendation. Salary: £1,800 rising to £2,100 p.a. A salary above the maximum may be paid in exceptional cases. Further particulars and forms of application are obtainable from the Registrar, Royal Technical College, Salford 5, Lancs., to whom completed forms should be returned as soon as possible.

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UNIVERSITY COLLEGE, IBADAN, NIGERIA

Applications are invited for the CHAIR OF PHYSICS. Appointment is to retiring age (normally 60). Passages paid for appointee, wife and up to five children under 11 years, on appointment, annual overseas leave and termination. Children's, car and outfit allowances. F.S.S.U. Part-furnished accommodation at rent not exceeding 7·7% of salary. Detailed applications (eight copies) naming three referees by December 30, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

THE SCIENTIFIC CIVIL SERVICE needs men and women for pensionable posts as (*a*) SENIOR SCIENTIFIC OFFICERS and (*b*) SCIENTIFIC OFFICERS in all major scientific fields, including Physics, Engineering, Chemistry, Meteorology, Mathematics and Biological subjects. Age limits: (*a*) at least 26 and under 32, (*b*) at least 21 and under 29. Extension for regular Forces service and Overseas Civil Service. Qualifications: normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment; additionally for (*a*), at least three years' relevant (e.g. postgraduate) experience. Selection by interview. London salaries (men): (*a*) £1,330–£1,640, (*b*) £730–£1,205; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting (*a*) S/53/60, (*b*) S/52/60. Closing date December 31, 1960.

SENIOR PRINCIPAL SCIENTIFIC OFFICER: DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. Pensionable post at Warren Spring Laboratory, Stevenage, Herts, for man or woman to lead research in chemical engineering and process development. Qualifications: normally first or second class honours degree in chemistry, physics, or chemical engineering; or high professional attainment. Research experience in the field of chemical engineering together with a sound knowledge of basic principles and theory, and an interest in basic research work essential. Works experience desirable. Salary scale £2,600–£2,950 (subject to review). Starting pay may be above minimum. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/5228/61. Closing date January 3, 1961.

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PHYSICIST OR PHYSICAL CHEMIST required by Ministry of Aviation, ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH, Hants., to work as SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER on problems of gas/solid interaction in one of following fields:—energy and momentum transfer, adsorption or chemical reaction. First or second-class honours degree (or equivalent qualification) and for S.S.O. (minimum age 26) three years' postgraduate research experience. Knowledge of ion sources, ion optics and mass spectrometry an advantage. Salary ranges: £690–£1,144; S.S.O.—£1,250–£1,540. Grade and starting salary according to age and experience. Superannuation under F.S.S.U. but opportunity for candidates under 31 (normally) to compete for established (non-contributory pensionable) posts. Housing available. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.517/OA.

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Applications are invited for the full-time post of RESEARCH ASSOCIATE IN PHYSICS. Candidates should possess a good degree in Physics or Grouped subjects, including Physics. The person appointed will carry out research work on the physical properties of substances in the powdered state in connection with a research contract placed with the College by the United Kingdom Atomic Energy Authority. Much of the work would be suitable for a higher degree. The post is tenable for three years. Salary £650 × £50–£750 per annum (under review). Application forms and further particulars from the Principal to whom they should be returned not later than 24th December 1960.

MINISTRY OF AVIATION, Royal Ordnance Factory, Cardiff, require CHEMIST OR PHYSICIST (E.O. grade). Knowledge of analysis of ferrous and non-ferrous metals, electric-plating solutions, etc., heat treatment, electroplating and metal finishing or knowledge of health physics associated with radioactivity and toxicity. Qualifications: Pass degree, H.N.C. or equivalent in Chemistry or Physics; G.C.E. (A level); G.C.E. (O level) with O.N.C. Salary: £1,045–£1,285 (minimum age 27). Opportunities (normally for those under 31) to compete for established posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting reference F.761/OA.

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Enquiries respecting these positions should be addressed to:

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*quoting ref. PB 1595K.*

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# SSSH...

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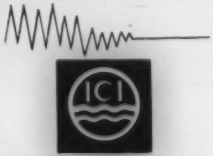


*Write giving brief details of age, qualifications and experience to:-*
**The Staff Manager,**
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**Billingham Division,**
**Billingham, Co. Durham.**
*quoting reference S/QQ.4.*

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**DUTIES:** Research and development in Physics mainly in the field of solid state and infra-red physics.

**QUALIFICATIONS:** Honours degree in Physics. Some research experience desirable.

**CONDITIONS:** Under specified conditions, first class air/sea transport for the successful candidate and dependants (wife and dependant children) will be provided by the Commonwealth. Assistance will be given in obtaining housing accommodation.

**APPLICATIONS:** Forms obtainable from the Senior Representative (AV.89/7), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged as soon as possible.

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Appointments are pensionable and carry attractive salaries. There is a profit sharing scheme and assistance can be given towards house purchase and removal expenses for married men.

*Write, giving brief details of age, qualifications and experience to :—*

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BILLINGHAM DIVISION,
BILLINGHAM, CO. DURHAM.
quoting reference S/PP.5.

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**I.C.I. (Heavy Organic Chemicals) Ltd.,**
**Billingham-on-Tees,**
**Co. Durham.**
**quoting reference P/WH/6.**

THE INSTITUTE OF PHYSICS

Vol. 11 No. 12 **BULLETIN** DECEMBER 1960

*Published by The Institute of Physics and The Physical Society*

# Selection for university education

Professor G. K. T. CONN
M.A., Ph.D.
*University of Exeter*

[A paper presented to the International Conference on Physics Education, Paris, July-August 1960]

SELECTION is necessarily invidious, frequently unfair, and often resented. This is as true of the selection of students for University entry as it is of selecting horses to back at the race-track. It is necessary to study the form—the school or stable where the candidates were trained, present performance as measured by recent successes, temperament, the type of race and the nature of the course. Backing horses is much simpler and safer than selecting students for University study; there are two reasons for this. The first is that the horse-race will be held in the near future, usually in the next half-hour while the University course extends over a period of years; "spotting winners" years ahead can only be described as a speculative gamble. The second reason is that horses are backed with your own money which sharpens the wits; students are backed with other people's money, the money of the University, the money of the candidate and his parents, the money of the state if an adequate number of scientists are to be trained. Responsibility for other people's money always introduces caution, it introduces the selector to the caution of seeking to show justice and the student to the caution of discharging a trust. This can, and for the student often does, introduce an element of humbug.

The age at which this selection takes place, the age of University entry is the age of late adolescence and that fact is very important. (At least it should be the age of late adolescence though some of the observed phenomena are commonly associated with early adolescence). When you are young it is ability that matters, professional ability backed by experience. The development and training of this ability begins at school and is continued at University. It is ability which opens doors, which offers opportunities. When you are older character predominates since it is character which determines professional stamina and *development* depends on character. A University should serve the individual in two ways. It should shape and point the training of his ability, it should bring him to terms with his intellectual capabilities. It should also be a forcing ground of character where he learns balance and proportion and the difference between obstinacy and consistency. In interviewing candidates for entry their attitude to other people's money gives of course most helpful insight into character.

Physics is now a well established University discipline and study. Moreover the vast majority of professional physicists are graduates who have obtained much of their professional training by University study. There is indeed a danger of assuming that all professional physicists are trained in a University. This is not true and never has been true; Michael Faraday for example had no formal University education and the profession must be careful never to insist that there is a single unique road to be followed. The qualifications accepted by The Institute of Physics in the United Kingdom[1] "as satisfying the academic requirements for corporate membership are:—An approved degree of a recognized University, the Institute's own Graduateship examination and the Diplomas (usually the Diploma of Technology in Physics) of a small number of colleges of technology specifically approved for the purpose. The Higher National Certificate in Applied Physics, specially intended for the part-time student, if obtained at 'credit' standard, can carry exemption from two-thirds of the papers of the Graduateship examination. Approximately the same exemption is granted to holders of those university degrees in physics which are not of sufficiently high standard to give full exemption." Having said that the road to the status of professional physicist is not unique, it is nevertheless true that the vast majority follow the University route and that all require as part of their training disciplined courses such as those indicated by a University degree. The elegance and rigour of Faraday's mind emphasize that for the best, "a course of study" should provide a guide and not serve as an end in itself. In a practical sense, therefore, the question of how does one select for University entry is, in the present context, how does one select physicists.

Several important factors must be clarified immediately. Physics, or as the Scots Universities term it, Natural Philosophy, which emphasizes the wide terms of

reference, was born during the 19th century which saw the co-ordination by experiment and theory of the separate sciences of mechanics, heat, optics, magnetism and electricity. To-day, Physics embraces an enormous range of human knowledge. Elementary physics is largely "classical physics" and I am never happy that in the Universities we are not guilty of a confidence trick. Students expect that at University they will study the physics they study at school, only more so. Industrialists complain that not enough attention is paid in Universities to classical physics. Physics as a science has grown up in the last 60 years. It has sired many sciences, electronics, acoustics, communications, nucleonics, electrical engineering, nuclear engineering. The elements of physics provide a basis for the professional study of many applied sciences and types of engineering. Each of these is a professional study, a discipline, a career in itself and every professional has a right to consideration for the title of physicist. This multiple fission, this diversity will become more pressing and more obvious as applications become more obvious and more significant industrially. Knowledge of principles, appreciation of fundamentals is vital to a training in physics; a *physicist* requires also experience of certain experimental arts, a grasp of a particular expertise. Broadly, universities offer a training in the principles in physics. In a first degree this should be of such a breadth that the student is provided with a basis for any relevant, professional expertise. The practical experience necessary for this expertise for a *physicist* can, or should, nowadays be provided in certain fields by postgraduate studies and by research; more often it is obtained outside the University. After his first degree, of three- or four years duration, a student is no more a physicist than a doctor without extensive clinical experience. The purpose of the "first professional course" is to examine and master the broad stream of intellectual ideas and concepts which bear on the quantitative study of the behaviour of matter. Put in this form it is a very ambitious programme !

A University is a community devoted to the pursuit of knowledge and a Professor of Physics has an appreciation of relative priorities which does not always coincide with say those of a Professor of History. If there were ever any conflict between the selection of a student for Physics and a student for study at a University, this would be a reflection on the place of Physics as a University study. In my experience there is, of course, never any such conflict. There is frequently a conflict between the responsibility of a Professor of Physics to Physics and a senior member of a University to the University. Thus in the light of benefit to the University something should be done though the money both could and should be spent for the benefit of Physics. This is usually resolved by obtaining the money for the particular project in Physics outside the University.

These are general comments which seem of fundamental importance. To illustrate from an allied but related field; it has always seemed to me to be short-sighted, confusing and disastrous that the teaching profession in the United Kingdom have accepted University criteria alone; there is no professional organization universally accepted. There is a Trades Union, the National Union of Teachers. University criteria may or may not be relevant in Physics—and I think they are—but they are not the only criteria, they are necessary but not sufficient.

In discussing University entrance we must establish who is being entered into what and for what purpose. The professional problems of training physicists are universal but the manner of solving them in a given context clearly depends on that context. This must be described in order to provide a frame of reference, for the selection can only be made clear in this way. The system in the United Kingdom, which is at present under considerable criticism, has faults: it also has certain merits when compared with other national arrangements. The opinions are those of a Scots-Canadian living and working in an English University.

### THE SCHOOL

The educational structure in the United Kingdom has the bizarre and unlikely vitality of Topsy who also "just growed." It is still "just growing" and is not the consequence of any single educational thesis or unique programme.

There is universal, compulsory education from 5 to 15. Most students enter University at about 18 and indeed many Universities will not accept them below the age of 17. The vast majority are graded at 11/12 years and divided into those who go into some form of "grammar school" where the education is essentially intellectual and designed for commerce and the professions, and those who go into secondary schools where the education is of a more practical nature. Two general points may be made. The educational structure in England, Scotland and Wales differs in background, tradition and administration though in many features the differences are more apparent than real. The second and most important feature is universal. It is no part of British policy to provide equal educational facilities for all pupils but as the White Paper which preceded the 1944 Education Act expressed it, "The keynote of the new system will be that the child is the centre of education and that, so far as is humanly possible, all children should receive the type of education for which they are best adapted."

There are three types of "grammar school." There are the grammar schools supported and controlled by local education authorities with the aid of grants from the Ministry of Education. Education, including books and materials, is free. In round terms these account[2] for 78 per cent of the whole "grammar school" population and they provide about 60 per cent of the University population. Next there are "direct grant" schools, usually of some antiquity, which are controlled by a board of governors and receive a direct grant from the Ministry of Education. There are conditions which such schools must fulfil to receive the grant, thus at least a quarter of the pupils must receive a free education, the fees of the remainder must be graded according to the parents' income, the local education authority must be represented on the board of governors. Such schools account for about 12 per cent of the "grammar school" population and provide about 13·5 per cent of the University population. Lastly there are independent

schools which are supported by their own endowments and the fees of the pupils; there are of course, a considerable number of scholarships. These are perhaps what are referred to as the Public Schools*; the name is an old one and was used to distinguish them from private education by family tutors. These independent schools, in general, have somewhat different traditions, recruit largely from preparatory schools, also fee-paying, have their own entrance examinations and provide a boarding school education from 13 to 18. Independent schools account for about 10 per cent of the grammar school population and about 18·5 per cent of the University population.

UNIVERSITIES AND UNIVERSITY EDUCATION

Before discussing school examinations which obviously loom large in University selection, it is necessary briefly to look at the Universities. The Universities are independent, autonomous, self-governing institutions set up by Royal Charter and in no way under Government or Ministry control. The machinery by which, under present conditions, Universities obtain something like 70 per cent of their income from the State and a large percentage of the capital required for building and expansion without State interference or control, is a wonder to behold. It also illustrates an extremely important principle of administration but for present purposes the important point is that the Universities are autonomous institutions. In academic affairs there is a universal tradition of external assessors who are appointed, each for a limited time, to act in all formal examinations. These assessors share, with the head of the department, responsibility for the examinations including setting and marking papers, conduct of oral and practical examinations and examination of any theses. The system is, of course, designed to ensure academic standards and keeps all departments under a permanent and perpetual inspection.

There are twenty-two Universities, sixteen in England, four in Scotland, one in Northern Ireland and a federal University in Wales; the number has grown since the war and is growing. These differ in background and evolution, they differ to some extent in outlook and organization. Broadly, there are five traditions which should be distinguished. Oxford and Cambridge are organizations of independent, residential colleges. For hundreds of years they were the only Universities in England and they exercise a great—in some respects excessive—influence on British University life. With the exception of St. Andrews, the Scottish Universities are largely non-residential, relatively old and have a characteristic degree structure. The four Welsh Colleges with a medical school in Cardiff, are organized in a federal University. London is unique. It is the largest University and in itself is an administrative system, rather than a University in the accepted sense. Under its statutes the University is required:

> "to hold forth to all classes and denominations, both in the United Kingdom and elsewhere without any distinction whatsoever an encouragement for pursuing a regular and liberal course of education, to promote research and the advancement of science and learning, and to organize, improve and extend education of a University standard."

This federal institution embraces a number of component colleges and co-ordinates and directs the work of many other colleges both at home and overseas by a system of "external degrees." The modern or civic Universities are a feature of the present century. All started as local colleges serving local interest and developed under the umbrella of the London external degree.

The ideal of a British University is that it shall be a community devoted to the pursuit of knowledge. They are unusual in a number of ways. As part of the tradition that a University is a place for a liberal education, they accept—particularly in England—responsibility for the living conditions and "moral welfare" of their students; it follows that some associated discipline must be imposed. This is not the custom on the Continent or in America. There was a great expansion at the turn of the century and there is an upheaval going on at present caused by a further large expansion. Thus the numbers of full-time University students in Great Britain was

| | | |
|---|---|---|
| in 1938/39 | ... ... | 50,246[3] |
| 1947/48 | ... ... | 76,764[3] |
| 1956/57 | ... ... | 89,866[4] |
| 1957/58 | ... ... | 95,442 |

In very round terms the present numbers are of the order of 100,000; present plans for expansion envisage 120,000 and recently the University Grants Committee have asked the Universities to examine further expansion by up to 40,000 places. This expansion has been associated with a shift of emphasis on two counts. The distribution by Faculties is as follows:—

| | 1938/39[5] | 1957/58[5] |
|---|---|---|
| Arts ... ... ... | 44·8% | 43·1% |
| Science ... ... ... | 15·5% | 22·8% |
| Technology ... ... ... | 10·5% | 14·5% |
| Others ... ... ... | 29·2% | 19·6% |

It is the intention that expansion of the sciences and technology should be proportionately much greater than in other subjects. At the same time the proportion of students who receive financial assistance has greatly increased; in 1935-36 the proportion was 41·1%[5] in 1946-47 it was 67·9%[4] and in 1955-56 it was 80·7%.[5, 6] This upheaval is changing and will continue to change the nature of the Universities. The phenomenon is not limited, of course, to any single country though there are certain peculiar features. "The modern English University is searching for a compromise between three ideas of University education acquired in the nineteenth century: the idea of the University as a school for the liberal education of gentlemen in character as well as intellect: the idea of the University as an institute de-

* The term "Public School" is neither officially defined nor used. "Independent Schools" includes all schools which would popularly be described as Public Schools and a number of others, for instance a number of "independent" Scots grammar schools which have a very small number of boarders. In round terms 70 per cent of the pupils at "Independent" schools are boarders.

voted to objective and disinterested research inherited from the German idolatry of *Wissenschaft*: and the idea of a University as a staff college of technological experts and specialists inherited from the continental polytechnic. It would seem that the modern English University will not admit that these three ideas may not be compatable."[7] In the popular mind the prototypes of these three are perhaps Oxford and Cambridge, the Institute of Advanced Study and the Massachusetts Institute of Technology.

The peculiar academic feature of the British University and the most important in the present context, is the Honours degree. This is the process by which the majority of professional physicists at present receive their initial training. The manner in which students are selected for, say, an Honours course in Physics has yet to be discussed; all of them have a number of years' experience of training including laboratory work before they reach the University. The pattern of studies over a period of three years* varies but is broadly as follows. In the first year, frequently regarded as probationary, Physics and Mathematics are studied together with a third subject, frequently Chemistry, occasionally Geology or even Psychology. The first two are generally compulsory; there is a considerable measure of freedom in the choice of the third. In the second year Physics and Mathematics are studied and in the final year Physics alone is studied. Lecture courses are provided and there are laboratory classes where each student is expected and helped to carry out a wide range of experiments for himself. Attendance at colloquia and certain seminars is expected. In many Universities a short thesis must be written in the last long vacation prior to the third year. During the last year they carry out a small experimental project lasting two or three months: this is not strictly a piece of research but is " original " to the student and it is designed to give him some experience in original work. Some measure of supervision or tuition whereby two or four students meet a member of the staff once a week to discuss difficulties and work done, is usually provided in the second and third years. At the end of the third year students are examined and graded, that is they are awarded first class, second class or third class honours. A weak candidate may be awarded a pass degree or may fail. The professional standard of the Honours degree is high: Payne,[5] who is an American, considers that it is roughly equivalent to the Master's degree of a good American University. In theory a student after completing an Honours course should be capable of starting research. To-day I am not certain that this training is adequate and, personally, I feel that in the British Universities we do not do enough postgraduate teaching.

### SCHOOL LEAVING, UNIVERSITY ENTRY AND THE PROBLEMS OF SELECTION

In the British educational system little emphasis is placed on regular and frequent tests. They are used, of course, to check progress and to develop powers of expression and expertise but for serious purposes a formal written examination, usually accompanied by a practical examination is set in all relevant fields of study. These are sometimes accompanied at Universities by oral examinations. Few Universities conduct their own entrance examinations and, even those which do, accept as equivalent performances obtained in the examinations of one or more of a number of approved examining boards. These boards are associated, with one or a group of Universities, for instance there is an Oxford and Cambridge Schools Examination Board, a Northern Universities Joint Matriculation Board, a Southern Universities' Joint Board for Schools Examinations, etc. Panels of examiners include members of University Staff and school teachers who serve by invitation and are paid for their work. These Boards, approved by the Ministry of Education, set examinations for school children and award a General Certificate of Education (G.C.E.). There are three levels of examination, the Ordinary Level taken at about 15 or 16 after three years study, the Advanced Level taken after a further two or three years study and the Scholarship Level taken by outstanding candidates—though not invariably—after three years of study. It must be realized that the primary purpose of these examinations is to provide an indication of attainment on leaving school. Certainly, and inevitably, they are used as a means of entry into the professions, including the Universities. Matriculation, that is minimal qualification for entry into a University varies but it will include a number of ordinary level subjects—usually English, Mathematics and a language are required and two passes at advanced level. The Advanced or A-level subjects are, in the case of physics, the basis for the honours degree, and almost invariably mathematics must be included. The peculiar characteristic of the grammar school is the VIth form in which the A-level subjects are studied. The VIth form is the climax of grammar school education, the teaching is or should be more personal, there is a measure of freedom to develop special interests, there is a responsibility for the control and discipline of the younger members of the school. Clearly when a candidate presents himself for consideration by a University he has some six years study of Physics behind him.

In spite of the fact that the whole educational system is essentially selective in the sense that no attempt is made to teach everyone the same thing, selection of University entrants is difficult and in recent years has been under considerable criticism partly because there is evidence of a real shortage of places and therefore competition for places. University education is an expensive business and it will be clear that there is no wide view in the country that everyone or the majority or even a large number " ought " to have a University education.†

It is felt that a student should not be encouraged to read for an Honours Degree in Physics, say, unless he has a

* In some cases this is four years in a Scottish University where the school education is less specialized.

† Perhaps the most revealing summary of this attitude was given in a report by the Association of University Teachers which bases an estimate of what the University population *should* be on the *proportion* of the population who had an Intelligence Quotient above a specified level.

reasonable expectation of getting some benefit out of it and of making some professional, that is academic, success of it. The real test comes near the end of his course in three years time: the examination data give a particular assessment at entry. Extrapolation is a notoriously dangerous exercise but one parameter is clearly performance in the A-level examinations in Physics and Mathematics. Unless the performance is well above a pass, the student is usually discouraged: how far above depends on a number of factors which include accommodation and the opinion of the Head of the Department which, in practice, is definitive. It should perhaps be made clear that once a student is accepted he is, by implication, guaranteed laboratory and lecture room accommodation and in many Universities housing accommodation either in Halls of Residence or in lodgings. The continental system whereby acceptance does not ensure accommodation is not British practice: and correspondingly migration while reading for a first degree is practically unheard of. Migration after the first degree is frequent though not perhaps common.

The first parameter then is academic performance to date: the second parameter is a confidential report from the candidate's Headmaster. And this, of course, depends on the school and the Headmaster as well as the candidate. I never get enough information from the Headmaster. The reports of some whose opinion I value, I trust explicitly; there are many whom I find less helpful. In my opinion the weight placed on the school report should be at least as heavy as on the examination results. It rarely is because it is rarely in sufficient detail. With schools and headmasters whom the department knows well the selection is relatively simple and I have on occasions offered a place to a candidate with poor marks. Usually—but not always—the Headmaster is right. At present both schools and Universities are faced with multiple applications, six or seven fold, which greatly adds to the work.

Thirdly there is an interview. This is not a universal practice, it is tedious but it serves both to introduce the candidate to the department, its circumstances and surroundings, and it enables the interviewer to see, or try to see, how his mind works. An experienced interviewer can rapidly winnow the memory-man, the dependent, well-drilled school-boy. One seeks a questing, empirical, quantitative mind. It is surprising how much one learns by asking solemnly "Do you believe in the absolute zero?" There is no magic in an interview; it is often of little help in distinguishing half-a-dozen earnest, faceless children but it does help in revealing motives, why they want to read physics, why they want to come to a University, why they want to come to this University—and the last parameter is what is the University of the candidate's choice.

As in all human activities selection can only be studied in the context in which the operation is carried out. That is why I have discussed both the school and the University system in terms of which our selection is carried out. Other systems require other procedures with which comparison can be made and it is always most interesting to compare with professional colleagues how they solve the same professional problems in a different background. Always for a decision we must see knowledge of two things, a candidate's ability and his purpose. His ability is relatively easy to assess; his sense of purpose, his conviction, how strongly does he want to pursue his course, how easily is he deflected, this is not easy to judge in adolescents. It is vital since this is what determines progress. Perhaps this is the merit of an interview, this and the opportunity of explaining to him precisely what he is in for. It is surprising how often he doesn't really know!

## THE UNIVERSITY EDUCATION OF GRADUATE PHYSICISTS

There is a problem of selection at graduation. Some, too few, go into teaching, some indeed many, go to industrial development, a few to industrial research and a very few continue at University for a period of post-graduate study. We assume far too readily in Britain that this should be a period of research and devote too little time and attention to systematic postgraduate teaching. The selection is based on analytic ability and an absorption coefficient. An analytic ability to probe essentials is most important, an ability to grasp new ideas and systematise new data is essential but original work requires also the ability to see new patterns in old ideas, to synthesise new experiments and seize on the significant. The Honours course is too crowded and cannot be carried to a sufficiently high level. We need, and we are beginning to establish, postgraduate teaching courses in specialized fields appropriate to the particular department in which there is an opportunity to develop these specialized skills, the insight which leads to successful research. Such courses being more specialized will be less academic in the sense that they are directed to a more specific end, that of training a man in the techniques of investigation in a particular field.

## CONCLUSIONS

There is a great and growing demand by industry for more scientists and technologists. This is complemented by the changing place of physics in the educational structure. In terms of the numbers of candidates sitting or successful at the Advanced level of the G.C.E. it is now much the largest experimental subject. The shift of educational emphasis is revealed by comparing numbers of Advanced level passes for 1956 with those for 1951 in the cases of history, which is perhaps the focal subject in a Faculty of Arts, and Physics.

| | *Percentage increase 1951 to 1956* | |
|---|---|---|
| | *Boys* | *Girls* |
| History ... ... ... | 9 | 22 |
| Physics ... ... ... | 46 | 66 |

The raw material is there in ever increasing supply: the demand for the product rises. Such a situation makes a manufacturer very happy. For those whose interest it is to train people, it is both a grave responsibility and a challenge.

I have discussed selection for University Education against the background of the British Universities. It would be both impertinent and silly for me to discuss any other context. Whatever the background, the same professional criteria arise, they are dictated by

Physics. There is first literacy, an ability to express oneself clearly and simply; it is difficult to accept that a candidate can think straight if he cannot write in direct terms. Second, there is need of a real driving interest in "What makes nature tick"; choosing a career is like choosing a wife, it will be a success if you get fun out of the drudgery. This drive is associated with a ruggedness of intellect which is rarely in conflict with the intellectual clarity and balance associated with initiative. Finally there is simple ability, mathematical ability and experimental insight.

Having said this, anyone of experience knows that the difference between the good and the bad is so obvious that there is little need of "selection." The problems arise when a higher resolving power is needed to discriminate a mediocre but densely populated spectrum. In the last analysis the best selector is the candidate himself and the real solution is to have sufficient accommodation to deal with all likely candidates. They can then sort themselves out. The important thing is not to be too sentimental and "kind." The best spectrometer is a rude but friendly, active and enthusiastic staff.


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5. A digest of the relevant statistics will be found in *Britain's Scientific and Technological Manpower* by G. L. Payne. (Stanford University Press (London, Oxford University Press), 1960.)
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# Notes and News

**Christmas holiday**

The offices of the Institute and Society at Belgrave Square and Lowther Gardens will close on Friday, December 23, in the early afternoon and reopen on Thursday morning, December 27.

**Subscriptions for 1961**

The January *Bulletin* will include a form that should be sent with remittances for 1961 subscriptions. Members are asked not to send subscriptions until this form is issued.

**Subscriptions of Members of long standing**

Council has approved the following rule:

"Members of 65 years of age who have been members for at least 20 years may, if they so wish, have their future annual subscriptions remitted, but they will then only be entitled to the Institute and Society's publications upon the same special terms as are current for Students".

All members whose subscriptions were remitted under a similar rule of either the Institute or the Society prior to amalgamation will, of course, automatically continue to have this concession. "Membership" in the rule means full membership of the Institute, the Society or the amalgamated body.

**International Commission on Physics Education**

Acting on a recommendation of the recent Paris conference on physics education, the International Union of Pure and Applied Physics has set up an International Commission on Physics Education. The President is Professor Sanborn Brown (U.S.A.) and the Secretary Mr. N. Clarke (U.K.). The other members are Professor D. Sette (Italy), Professor A. Michels (Holland), Professor P. Fleury (France), and Professor J. Tiomno (Brazil); a Russian member is to be appointed. There are also corresponding members from Czechoslovakia and the United Arab Republic.

*Vol. 11, December, 1960*

# The requirements of industry for physicists* (1)

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[A lecture given to the Conference of the Education Group and the Midland Branch on April 22, 1960]

## INTRODUCTION

At this session we are dealing with the requirements of industry against the background of sessions which have dealt with various aspects of university and diploma in technology education as well as postgraduate work. The accent, then, is on the requirements of industry with respect to people having a university degree or its equivalent, but we must certainly not ignore those who are following different routes such as National Certificate courses.

We should perhaps consider briefly what should be included in the term "industry." Apart from manufacturing industries, many physicists are also employed by various government establishments and by research associations, and some of these will certainly be working closely in conjunction with industry, so that their requirements are similar. It seems, in fact, that we exclude only the educational fields of university, technical college and school, where again many physicists are employed.

With this interpretation of industry, we can consider a general sub-division into two types of activity in which physicists may find themselves. Firstly, they may be engaged by industries which can be regarded as physical in themselves, such as instruments, electronics and some portions of the electrical and nuclear power industries. On the other hand, they may be employed by industries which are basically chemical, metallurgical or engineering and where their knowledge and skills as physicists provide essential, but nevertheless ancillary, information to support the work of chemists, metallurgists or engineers. I have no experience with industries of the former type, but, as is apparent, I am employed by a chemical company in a metallurgical facility, and this fact provides me with the opportunity of presenting data which I hope will be of interest. The Company is engaged in a very wide range of activities, which represent a fair cross-section of manufacturing industry in this country, admittedly with a chemical bias. The manner in which it employs physicists should, therefore, provide a reasonable basis for examining the requirements of those industries which, in themselves, are not of a physical nature. I should point out, however, that the data on which I have drawn represents the present position, whereas technical requirements and educational facilities are changing continuously. Thus, in his survey of available places for physics students in universities and technical colleges (*Bulletin*, June 1958), Mr. Clarke points out that between 1949 and 1955 there was little change in admissions to honours courses in physics. The number, however, had increased by 55% by 1957 and expansion of physics departments is still going on. Such facts must be noted in assessing the future position.

## STATISTICAL DATA ON EMPLOYMENT OF PHYSICISTS

In discussing physicists employed by my company, we must be quite clear as to how we are defining a physicist. The definition I have taken is a person who has an honours degree in physics or an equivalent qualification. It excludes people with general degrees, but includes pass degrees obtained at the end of an honours course. This definition appears to fit best the general background to this conference. The total number of such physicists employed by the Company is 305, the end of last year being taken as the datum line. This number in itself raises several questions. Is it a reasonable number, and does it provide any indication of the likely numerical requirements of industry ? It includes people of all ages, and we may take it that the average working life in industry is of the order of 40 years. The average yearly intake has been therefore of the order of eight people, which should be increased to about ten to allow for turnover. However, the present rate of recruitment is of the order of 12-20 per year, but this increase is probably no greater than that for other disciplines.

The rate of recruitment is illustrated to a certain extent by the age distribution, which is :—

TABLE I

| | |
|---|---|
| Under 32 years | 120 |
| 33-42 years | 129 |
| 43-52 years | 39 |
| 53-62 years | 17 |
| | 305 |

The broad implication is that the rate of recruitment has been of the order of 12-13 over the past 20 years, and it may well have been higher to allow for turnover in the younger age groups.

The ratio of chemists to physicists in the Company is about 10 : 1, whereas the ratio of membership of The Royal Institute of Chemistry and The Institute of Physics is about 3 : 1. The only conclusion is that this sort of comparison provides no useful yardstick, and indicates that the Company has a substantial chemical bias. On a national basis, the total working population is reputed to be 23,000,000, and I am making a broad assumption that about half of these are engaged in industries which could benefit from employing physicists. The number of employees in the Company under consideration is 110,000, or about 1% of half the total. On this basis, there should be about 30,000 physicists in industry. Allowing a working life of 40 years, the implication is

* A second article on this subject, by Dr. R. E. Bastick, will be published in the January 1961, *Bulletin*.

that the universities should be turning out 750 graduates a year for industry alone. Many physicists are engaged in education and government service, so that present annual intake of 1,400-1,500 into university honours courses in physics appears to be of the right order. On the other hand, the present rate of recruitment by the Company would indicate that more than 1,200 physicists a year are needed by industry, and this gathering might be led to deduce that there is an inadequate awareness in industry generally of the value of physicists. Perhaps these calculations only serve to emphasize the oft-repeated statement that more technologists and scientists are needed, including physicists.

Interesting facts emerge from breaking down the total of 305 in other ways, firstly by qualifications :—

TABLE 2

| | |
|---|---|
| Ph.D. | 52 |
| 1st or 2nd class | 183 |
| 3rd class or pass | 57 |
| *Other | 13 |
| | 305 |

* (" Other qualifications " include mostly those from colleges of technology).

I should like to know whether these numbers are representative of the various types turned out by universities. For instance, is the proportion of people proceeding to postgraduate work about one-sixth of those who graduate ? Similarly, does about one-sixth of those sitting final examinations obtain a 3rd class or pass ? It is fair enough to assume that all these people have been usefully absorbed into industry, and that if the figures are representative then there is a good prospect that a similar distribution could be usefully absorbed in the future, provided the standard is maintained.

It is the custom in the Company to describe a graduate who is engaged in physical work as a Technical Officer (Physics). Of the 305 people, 214 are so described, and 91 are described as Technical Officer in some other discipline, although their initial qualification was in physics. It is worth noting also that some 44 people, additional to the 305, were initially qualified in subjects other than physics, but are now described as Technical Officer (Physics). At first sight, this might appear to be a regrettable trend in that the skills and knowledge acquired at university are being wasted. Certainly some of the more obvious skills may not be employed explicitly, but we shall see later that the intellectual ability resulting from studying and applying a subject like physics is probably a man's best asset. After several years, demarkations between the various disciplines become much less pronounced, and people are able to migrate with advantage from one to another. We have, of course, the parallel cases of lawyers turning into company secretaries and accountants into general managers. The fact that more physicists are going to other disciplines than the converse may be taken as a compliment, because it suggests that physicists, by the nature of their skills, are more mobile than others.

The breakdown of the 305 by type of employment is:—

TABLE 3

| | |
|---|---|
| Research and Development | 157 |
| Production | 66 |
| Other technical activities | 61 |
| Non-technical | 21 |
| | 305 |

About half the total is in research and development. This figure should be related to a general policy of the Company, which is to engage people like physicists initially in a research activity, and then, depending on their own ability and choice and on available openings, to transfer them to other jobs. The youngest people will therefore be found preferentially in a research department, but on the other hand there are several physicists with long service still engaged in research. On balance, there seems to be a 50 : 50 chance that a physicist will move out of research into another department.

A two-way classification, by type of qualification and by type of employment, is illuminating.

TABLE 4

| | *Research and Development* | *Production* | *Other Technical* | *Non-Technical* | *Total* |
|---|---|---|---|---|---|
| Ph.D. | 41 | 5 | 3 | 3 | 52 |
| 1st and 2nd class | 91 | 40 | 43 | 9 | 183 |
| 3rd or pass | 18 | 20 | 10 | 9 | 57 |
| Other | 7 | 1 | 5 | 0 | 13 |
| | 157 | 66 | 61 | 21 | 305 |

This demonstrates that the 50 : 50 chance applies to 1st and 2nd class graduates, but that Ph.D.'s are found almost wholly in research and development, whereas those with a 3rd class or pass degree are employed preferentially in other departments. We can conclude, I hope, that the Ph.D.'s have shown that they have profited from their training in research at universities, and, in fact, are enthusiastic to continue research in industry. Enthusiasm is a very worthwhile attribute, not always easy to live with, but it provides the motive power for much research, and other, activity. Is there a tendency for it to be less prevalent now amongst young graduates than it was twenty years ago ? We may also conclude that people with lowly degrees have intellectual abilities which, although perhaps not suitable for research, enable them to undertake other worthwhile activities. There is a similar indication of this trend in the fact that of the 57 people with 3rd class or pass degrees, 32 are not now described as Technical Officer (Physics).

I feel it only fair to provide an indication of salary levels, mainly as a guide to advancement, but this information must be guarded, because it relates not only to some of my immediate colleagues but also to my friends in other Divisions. In the Company a maximum salary is assigned to each job, and the man holding that job may expect to reach the maximum within a reasonable period if he is not already receiving it. For my purpose only, and as examples, the relevant Job Maxima

have been divided into three groups, (1) those equal to or greater than £2,710, (2) those of £1,895 or greater, but less than £2,710, and (3) those below £1,895.

There are no particular reasons for choosing these limits, except to provide reasonable numbers in each group from which useful comparisons can be made. The actual numbers are :—

TABLE 5

| | |
|---|---|
| Group 1 | 34 |
| Group 2 | 70 |
| Group 3 | 201 |
| | 305 |

i.e. about one-third of the people are in the higher brackets. A break-down by type of qualification indicates that there is little difference in salary structure between the grades, and, in particular, that the 3rd and pass degree people may have abilities which give them the opportunity of progressing as well as other people.

TABLE 6

| | *Group 1* | *Group 2* | *Group 3* | *Total* |
|---|---|---|---|---|
| Ph.D. | 6 | 15 | 31 | 52 |
| 1st and 2nd class | 19 | 37 | 127 | 183 |
| 3rd and pass | 7 | 13 | 37 | 57 |
| Other | 2 | 5 | 6 | 13 |
| | 34 | 70 | 201 | 305 |

The manner of progress is illustrated by a further breakdown into types of employment :—

TABLE 7

| | *Research and Development* | | | | *Other Departments* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Group 1* | *Group 2* | *Group 3* | *Total* | *Group 1* | *Group 2* | *Group 3* | *Total* |
| Ph.D. | 3 | 11 | 27 | 41 | 3 | 4 | 4 | 11 |
| 1st and 2nd | 8 | 15 | 68 | 91 | 11 | 22 | 59 | 92 |
| 3rd and pass | — | 1 | 17 | 18 | 7 | 12 | 20 | 39 |
| Other | 1 | 3 | 3 | 7 | 1 | 2 | 3 | 6 |
| | 12 | 30 | 115 | 157 | 22 | 40 | 86 | 148 |

There are greater proportions in the higher salary brackets for people employed in departments other than research and development, more particularly noticeable for the Ph.D. and 3rd or pass groups. In fact, the latter have maintained parity with the others because of their tendency to employment in deparuments other than research. However, to assess the position properly we must also look at the age distribution by qualification, which is :—

TABLE 8

| | *32 and under* | *33-42* | *43-52* | *53-62* | |
|---|---|---|---|---|---|
| Ph.D. | 19 | 22 | 7 | 4 | 52 |
| 1st and 2nd | 83 | 73 | 21 | 6 | 183 |
| 3rd and Pass | 17 | 29 | 7 | 4 | 57 |
| Other | 1 | 5 | 4 | 3 | 13 |
| | 120 | 129 | 39 | 17 | 305 |

It will be noted that the age distribution for 3rd and pass degree people is not significantly different from that of the remainder, and that the small number of people with " other qualifications " tends to be in the older groups, as would be expected. In fact, salary distribution and age distribution are substantially uniform over the various qualification groups. The particular point of salary distribution with respect to type of employment can be resolved by considering a further break-down by age (see Table 9).

The general age distribution is very similar for the two types of employment, and the pattern is repeated throughout the various qualification groups. The advancement resulting from transfer from research to other departments is not therefore age-dependent.

To summarize the conclusions from this statistical survey, it seems that industry can employ, usefully and progressively, physicists with qualifications of all types. Many can expect to find themselves eventually in jobs other than physics and in departments other than research or development. The chance of advancement, as gauged by financial reward, does not appear to depend to any marked extent on type of qualification, but it is certainly enhanced by mobility and the capacity to apply knowledge and ability in spheres other than that initially envisaged. I should perhaps mention again that these are deduced from an industry which is not primarily physical, and, therefore, comments from those engaged in other industries would be most welcome.

## REQUIREMENTS FOR RESEARCH AND DEVELOPMENT

I now wish to turn to a different aspect of this subject, and to examine requirements with respect to knowledge, skill and ability in some of the circumstances we have already been considering. I do not wish to stress the

TABLE 9

| | *Research and Development* | | | | | *Other Departments* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Under 32* | *33-42* | *43-52* | *53-62* | | *Under 32* | *33-42* | *43-52* | *53-62* | |
| Ph.D. | 16 | 17 | 6 | 2 | 41 | 3 | 5 | 1 | 2 | 11 |
| 1st and 2nd | 41 | 35 | 11 | 4 | 91 | 42 | 38 | 10 | 2 | 92 |
| 3rd and Pass | 4 | 12 | 1 | 1 | 18 | 13 | 17 | 6 | 3 | 39 |
| Other | 1 | 3 | 1 | 2 | 7 | — | 2 | 3 | 1 | 6 |
| | 62 | 67 | 19 | 9 | 157 | 58 | 62 | 20 | 8 | 148 |

obvious, but nevertheless I think it worth while pointing out that a physicist engaged in an industry other than physical, must have the background which will enable him to keep in step with his chemical, metallurgical or engineering colleagues. Furthermore, he must be prepared to study the other man's subject. For example, the man investigating the mechanical properties of fibres must be able to learn quite a lot about polymer chemistry. Other numerous examples could be quoted. This is no more than an argument against too early specialization and the crowding out of the syllabus of subsidiary subjects.

With the background that half the physicists are employed in research and development, it is interesting to list some of the research activities which are undertaken by the Company. These include calorimetry ; electron diffraction and microscopy ; X-ray crystallography ; nuclear magnetic resonance spectroscopy ; optical spectroscopy, ultra-violet, visible and infra-red ; labelled atoms ; mass spectrometry ; ultrasonics ; magnetic susceptibility, microscopy ; colorimetry ; properties of surface films on liquids ; formation, shape and growth of crystals ; rheology ; properties of aggregates, polymers and fabric materials ; general mechanical and dielectric properties ; semi-conductors ; and a variety of miscellaneous physical measurements. This rather dry and superficially uninspiring list is so comprehensive that it would be unreasonable to expect a new graduate to have any great facility in a few or even one of them. There are, of course, occasions when postgraduate research can be applied directly to current problems and where the man concerned fits an immediate vacancy. The object of postgraduate work, however, is not to prepare a man for a current need but to guide him in independent thinking, and to develop his intellectual capacity. The straight graduate also should have the fundamental knowledge to enable him to apply himself to any project. such as those in the above list, and to make his own contribution to the work. A more important consideration, however, is that the list will be substantially different in 10 or 20 years' time. The man graduating now, and who may be expected to be assuming responsibility for the work of others in 10 or 20 years, will need the flexibility to adapt himself to such changes, and will gain this flexibility through a thorough grasp of his subject and exercise of his powers of independent thought.

It is worth while looking at one or two examples in greater detail, to see something of the demands that are likely to be made of a physicist investigator. Colorimetry sounds a dullish subject, if it is restricted to determination of the spectral characteristics of solutions, suspensions or solids, perhaps reducing them to tristimulus coefficients, or using instruments to measure the whole lot automatically. But when the use made of these measurements is considered, the subject becomes much more interesting. Matching the colour of a dyestuff or a paint has always been regarded as a highly skilled operation. Colour measurements in themselves do not help greatly, because the expertise in knowing what process modification to introduce when a match is not quite achieved is still required. It is necessary therefore to establish quantitative relationships between raw material and process variables on the one hand and colour values on the other. This is a long and complicated programme to which plant engineer, chemist and physicist will all contribute. Each will need to know the point of view, problems and skills of the others, so that they may settle down into a progressive team. The physicist in particular will need to design his experimental procedures, and possibly to design new equipment, to fulfil the needs of his colleagues, and if necessary to be anticipating them. In a lengthy experimental programme of this sort, decisions will have to be taken at intermediate stages, for which insufficient information is available, decisions to modify plant or process, or to re-direct investigations.

As a second example we may take spectroscopy, which is often employed for analytical purposes, infra-red absorption for organic materials, and ultra-violet emission for metals. Everyone recognizes the importance of analytical information, both for research and production purposes, from the point of view that properties and characteristics are almost invariably related to composition and forecast by reference to it. The consequence is that analysts—and their numbers include several physicists—come into contact with the work of most of their colleagues, and they again need to know something of the other man's problems, enough to be able to apply their analytical skills to the best advantage. Furthermore, the analyst, particularly the physicist, will be required to devote his abilities to the design and operation of instruments for continuous or substantially instantaneous indication of the operations of plant processes. This will call for very considerable knowledge of plant operation, of the factors likely to affect composition and of the requirements of plant management. Judgement will be needed to decide the best apparatus to use in particular circumstances, what its limitations are, and what staff is needed to operate it.

What emerges from these two examples ? The physicist, like any other scientist, must use his intellectual powers not only in connection with his own particular activities, but also in relating them to those of others. He has to be a good team member, but this means much more than getting along well with other people. It means being able to present his own viewpoint and background to his colleagues, to discuss and if necessary defend his statements, to be able to appreciate the other man's discipline and to accept his thoughts and arguments. In other words, he must be able to express himself in writing and in speech clearly, accurately and logically.

This applies generally to all scientists and technologists ; what has the physicist to offer in particular ? He has, of course, his techniques and experimental skills, and moreover the basic physical discipline of hypothesis, experiment, law and logic, cause and effect. Although this discipline is now common to most sciences, there are occasions when the other man needs to be reminded of some fundamental fact or principle. Thus, the intricacies of electrochemical processes, which can be confusing when one is immersed in them, are much clarified when they are related to Ohm's Law, and I have known occasions when chemical colleagues have been much assisted thereby. Again, heat transfer is important in

boiler operation, and is likely to be taken into account when considering factors affecting the growth of protective oxide films on boiler tubes. However, it is difficult to appreciate how an oxide film could be affected by a flow of heat through it, and, having examined the cause system, it is more rewarding to consider oxide films in relation to temperature and temperature gradients. These examples are, of course, very simple, but they serve to illustrate the types of contribution which the physicist may be able to make.

We can now perhaps summarize the requirements of industry with respect to physicists engaged in research and development activities. The research investigator, of course, needs to know his physics, and examination results are usually accepted as sufficient evidence of his ability in this respect. More particularly, the physicist should be able to use scientific method in his investigations, to disentangle cause and effect, to demonstrate experimental and observational skills, and to think logically both in concrete terms and mathematically. He should be able to apply this intellectual ability to the problems with which he is presented. He will need, furthermore, to have a sense of judgement in deciding which way to proceed, frequently on incomplete evidence, and by weighing up the pros and cons to provide unequivocal advice to his colleagues. As he progresses, his initiative should develop so that, in addition to applying his skills to problems presented to him, he will himself be able to formulate investigations in which his own background and experience can be used to advantage.

The question of expression in writing and speech merits some amplification. During his student days, the budding scientist is writing essays and answering examination papers, knowing that the people who will read them have a greater knowledge of the subject than he has. His objective, in fact, is to demonstrate his erudition and to impress examiners and tutors with his knowledge. In industry, the converse is almost invariably the case. A report is written to guide and inform people who generally know much less about the subject than the investigator, the objective being to initiate action, such as change in product or process. The recipient of a report will want to know why the work was undertaken and the background to it, and the conclusions and recommendations that arise from it. The experimental work and discussion of results will be recorded to link the one logically with the other, and also for the benefit of future investigators. The whole document should be clear to the non-expert and should be written so that they can follow the argument, although they may not be in a position to criticize it. The manner in which an investigator is able to order his mental processes is perhaps shown more clearly in his reports than in any other way, and his degree of success will frequently be judged on the documents he writes, which are the only products of his activities. I am not suggesting that universities or colleges should undertake specific training of students in report writing, because this is a task which is best undertaken by employers. However, it would be well to remind students that, when they are in industry, any attempt to blind recipients with science or to write down to them is almost bound to be resented.

### REQUIREMENTS FOR OTHER ACTIVITIES

We have considered mainly hitherto requirements for people engaged in research and development, but we have seen that about half the physicists in, at any rate, one industry migrate into other activities. What qualities are then required ? The brief answer is that they are very little different from those discussed above, but there will be differences in degree rather than in kind. A man engaged in production, for instance, will have to cope with problems in the procurement and assessment of raw materials, in designing and maintaining production schedules, and in satisfying customers' demands. He will also be accepting and implementing results and recommendations arising from research work, and will be feeding back problems to his research colleagues. He will need, therefore, the fundamental background knowledge that will enable him, at least, to appreciate recent advances, and to know how they can be applied to his problems. His experimental and observational skills will still be of value, not so much in direct application as in assessing behaviour of plant and quality of final product. This is perhaps becoming of increasing importance with greater instrumentation of plant. The production man will need to know something of the operation of such instruments and of the reliability of the readings which they present. His judgement and initiative will still be major assets, and they are based firstly on his scientific training and secondly on his experience, for instance in tackling research problems. In fact, the men with good judgement, initiative and expression will be selected for advancement, almost independently of their qualifications. The main difference between research and production activities is that the former are long term and the latter, because of their greater variety, necessarily of shorter term. Similar considerations apply to other activities such as technical liaison with customers.

### SELECTION AND TRAINING FOR DIPLOMA IN TECHNOLOGY

The first two Sessions of this Conference were devoted respectively to "Problems of Selection for Diploma in Technology and University Degree" and "The University Degree and Diploma in Technology Compared as a Training for the Industrial Physicist." It seems, then, that I should say something on the industrial view-point with respect to these two sessions. It is, of course, much too early yet to be able to make any precise statements regarding the dip. tech. people. The first stream of qualifiers is just trickling through, and we shall all view their progress with great interest.

Selection for university and college is only one stage of many that extend from the 11-plus examination to choosing the Chairman of the Board. As we have seen, the graduate will be selected by industry on the basis of his knowledge, judgement, initiative, co-operativeness and powers of expression, but there are very few graduates who fail to find a job. Similarly, there are very few school leavers who, being worthy of a university place and wishing to find one, fail to do so. Clearly, standards of selection are different in different places, not necessarily better or worse, but only different. With the emergence of works-based sandwich courses, industry is playing a greater part in the selection of students for

diploma courses. While scholastic requirements must be met, industry will pay considerable attention to individual characteristics in choosing its students.

It is well to remember that the student or graduate has powers of selection, as well as university, college or employer. If the number of university places is adequate to meet demands, and if all school leavers wishing to study physics select the university route and are accepted, there would be no problem of selection for dip. tech. courses. There would be no students to select. Recent and projected expansions in universities could lead towards this situation, in which a diploma course would be regarded as a second inferior choice. The consequences would be small intake of low quality into such courses, and a degradation of the status of the diploma, all of which would be regrettable and detrimental. Action with respect both to quality and quantity lies, I would suggest, with industry, for whom the sandwhich courses were specifically designed. They must not let selection be exercised only by student and college, but, having decided how many physicists are needed in sandwich courses, take action to attract into them the types of people who are likely to repay the considerable cost.

The type of training to be given in diploma courses depends to a certain extent on the likely activities in ten or twenty years of people who have taken them. At present, this can only be a matter for speculation. I favour a period in research for such men, because it stimulates the intellect and increases confidence in one's own abilities. The title of their qualification indicates that they are expected to be the technologists of the future, which raises the question as to what a technologist does. I believe he is generally regarded as the man who takes the results of recent researches and applies them in his own field. He needs, therefore, the fundamental knowledge to keep up-to-date, the judgement to know what is going to be of benefit to him, and the initiative to get it introduced. This is the same specification as we have outlined above. In fact, a great deal of technical activity in industry, apart from a small proportion of fundamental research, is technological in character, and has been conducted hitherto by university graduates. If his training periods in industry are closely geared to his college training, the sandwich course man should have the advantage that he should gain an earlier appreciation of the way in which fundamental knowledge is applied to technological problems.

### TECHNICIANS

When discussing scientists and technologists, we must certainly not forget the technicians. The annual number of university graduates in physics is of the order of 1,300. On the other hand, the number of candidates for the Higher National Certificate in applied physics was just under 300 in 1959. The disparity is so great as to raise the question—who supports the work of the graduate physicist, or is he responsible for all his own experiments, observations and apparatus ? While appreciating that the National Certificate courses in applied physics have only been operating for some seven years, and that the rate of increase has been considerable, there does seem to be a need for much greater numbers of such people. I have heard the opinion expressed that a National Certificate in applied physics will provide the holder with a greater degree of flexibility than corresponding certificates in, say, instrument technology. The recent recommendations from the Institute on National Certificate courses for technicians working in instrumentation and automatic control grafted instrument technology on to applied physics, which seems to be the right way. However, it does lengthen the course. Once again, it seems to me that industry must decide whether it needs technicians in applied physics, electrical engineering or instrument technology, and direct its employees accordingly. I am, of course, biased in the same sense as the other members of this Conference in feeling that benefit would be obtained from directing more people into applied physics courses.

### CONCLUSIONS

I have perhaps been overlong in stating a few very simple facts. Industry requires people with good fundamental knowledge and intellect, the ability to apply that knowledge with judgement and initiative, and well-rounded personalities. Physicists in particular can use in industry their experimental, mathematical, instrumental and logical skills to the mutual advantage of themselves and their employers. While this is hardly the time to discuss the ethics of industrial activity, two observations would perhaps not be out of place. The industrial physicist should be objectively honest with himself and with his employers, and he should regard his fellow employees, of whatever status, as individual human beings.

*Vol. 11, December, 1960*

# The Diploma in Advanced Studies in Physics at Manchester University

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THE Diploma in Advanced Studies in Physics and Allied Subjects was instituted at Manchester University in 1958. Its original purpose was to provide a one-year postgraduate course in physics as an alternative to the traditional postgraduate research work, which leads to the degrees of M.Sc. or Ph.D. In its first year this course was sufficiently successful that it was decided in 1959 to require all research students and Advanced Course students in physics to take the Diploma during their first year, unless granted special exemption on the grounds of previous postgraduate experience. The Diploma has thus been made the normal preliminary qualification for entry to further research work leading to higher degrees.

Diploma candidates are required to attend at least three approved postgraduate courses in each of the 1st and 2nd terms, and to sit written examinations on these; to undertake an experimental or theoretical project of a research nature under supervision, and to submit a written report on it; and to sit an oral examination on the courses attended, and on the project and related topics. At Manchester University, the Departments of Physics, Theoretical Physics, Radio-Astronomy and Astronomy form an integral unit for teaching purposes, and consequently a very wide choice of courses and lecturers is available. The list of two- or three-term courses in the current session includes:

1. Quantum mechanics
2. Statistical mechanics
3. Field theory
4. Theoretical nuclear physics
5. Mathematical methods of physics
6. Selected topics in experimental nuclear physics
7. Instruments of nuclear physics
8. Solid-state physics
9. Physics of organic molecules
10. Optics and spectroscopy
11. Current work in radio-astronomy
12. Stellar astrophysics
13. Structure and evolution of the galaxy

In addition one-term courses are being given on:

14. Low temperature techniques
15. Low temperature physics
16. Crystal structure and crystallography
17. The solar system
18. Stellar and galactic astronomy
19. Elementary particles
20. Physical applications of Fourier transforms

The range of courses reflects the variety of research interests of the Department, and it is usually possible to select a combination of courses to suit the particular needs of any individual student. In addition, however, certain postgraduate courses in the Departments of Pure Mathematics, Applied Mathematics, Chemistry, Nuclear Engineering and Electrical Engineering may also be approved for the requirements of the Diploma in Physics, provided that only one such course is offered in each term for examination purposes.

In addition to these formal lecture courses, various postgraduate seminars and colloquia in Nuclear Physics, Theoretical Physics, Molecular Physics, Optics, Astronomy and Radio-Astronomy are held throughout the session, and Diploma students are encouraged to attend any of these which are of interest to them.

The written examinations are held in January and April, near the start of the 2nd and 3rd terms respectively, to allow the students the Christmas and Easter vacations for the digestion of the previous term's work. Each examination consists of a single 3-hour paper, divided into sections corresponding to each of the courses of the previous term, and candidates are required to answer one question from each of three different sections.

Each student is allocated to a supervisor, who is responsible for the direction of his experimental or theoretical project work. In the case of a potential Ph.D. student, the project is normally undertaken in one of the specialist research groups and corresponds to the initial stages of his ultimate research studies. A potential M.Sc. student may also undertake his project work with a research group, to enable his particular interests to be met. The majority of Advanced Course students and those who do not wish to proceed beyond the Diploma undertake their experimental project work in the Advanced Laboratory, where they can receive more detailed supervision and training in experimental techniques. All students of experimental physics are also allocated to a tutor, who advises them on any special problems encountered in their studies in theoretical or mathematical physics. Some typical projects undertaken for the Diploma are as follows:—

(*a*) Measurement of neutron energies and angular distributions in (d,n) reactions. (H. Ceulemans, 1959);
(*b*) A helical - focusing lens beta - spectrometer (D. C. R. Williams, 1959);
(*c*) The semi-conductor radiation detector (J. M. Watson, 1960);
(*d*) The design of an instrument for the study of organic fluorescence decay (D. J. Dyson, 1960);
(*e*) The design of a focusing system for secondary particles for subsequent acceleration (D. J. Jones, 1960);
(*f*) An investigation of a gas scintillation counter with applied electric field (C. A. N. Conde and A. J. P. L. Policarpo, 1960);

(*g*) The propagation of second sound in rotating liquid helium (R. H. Bruce, 1960);
(*h*) Solid-solid boundary resistance at low temperatures (K. Roe, 1960);
(*i*) The ground-state of a many-boson system (M. J. Halsall, 1960);
(*j*) Single pion production in pion-nucleon scattering (B. R. Pollard, 1960).

The project report, which corresponds to a minor thesis, is prepared and submitted for examination during the 3rd term. The oral examination, which is held towards the end of June, is of about one hour's duration, and is conducted by a panel of three examiners. Some candidates may also be required to attend a further oral examination conducted by the external examiner.

The Diploma may be awarded with distinction. Candidates who wish to proceed to a research degree are required to have shown satisfactory evidence of research ability in their project work. Those wishing to enter the M.Sc. course (1 year) are required to satisfy fully the requirements for the award of the Diploma. Those wishing to enter the Ph.D. course (2 years) are required to have reached a high standard in the Diploma examination as a whole.

The Diploma course appears to offer many advantages compared with the traditional methods of postgraduate training and research. It is highly flexible and it can be readily adapted to meet the needs and interests of the individual student. It provides a more reliable mode of selection and of assessment of potential research ability than one based solely on the results of the Honours degree examinations, since it tests a student's ability to learn and understand more advanced physics, to undertake experimental or theoretical research, to write a lucid account of his work, and to discuss intelligently the results of his studies.

The Diploma course provides a natural sequel to the Honours physics course, and its introduction has greatly facilitated the development of a well-balanced Honours physics course at Manchester, by excluding specialist courses in subjects which are more appropriately studied at the postgraduate level. The Diploma has also proved an excellent introduction to postgraduate work in physics for students whose previous education has not been in a British honours physics school. Students from overseas Universities, where standards may differ from those in Britain; students who have taken " sandwich " courses leading to a Diploma in Technology; students who have qualified through the Graduateship examination of the Institute; these are representative of those who have found the Diploma course adaptable to their needs.

The Diploma course caters for three distinct categories of students. There are those who sense certain inadequacies in the broad studies of the Honours physics school as a direct introduction to a career in an industrial or Government laboratory. They therefore undertake the Diploma course in order to acquire specialist knowledge and experience in some branch of physics, and to become acquainted with advanced techniques and methods. It is earnestly hoped that their future employers will come to appreciate the value of the Diploma in this respect. Apart from potential industrial physicists, those intending a career in technical college education have found the course of particular value. Other Diploma candidates have included young research workers from overseas institutions who have been sent to the Department for a 1-2 year period of training and experience in some special field.

The second category of student is the man who takes the Diploma at the end of the first year, and completes his research training in the second year (attending further lecture courses if he wishes) by undertaking some original research which may be submitted for the degree of M.Sc. Such students are eligible for D.S.I.R. Advanced Course Studentships, which are tenable for a 2-year period covering the course outlined.

The third category of student is the potential Ph.D. candidate. He normally takes the Diploma in his stride in the first year, more often than not achieving distinction standard, and proceeds in the following two years to undertake further research leading to the Ph.D. degree. Such a student normally holds a D.S.I.R. Research Studentship or equivalent. These students have benefited greatly from the introduction of the Diploma course. The slackness and lethargy which can so often beset the most brilliant student, when he is released abruptly from the rigours of the Honours school into the free, apparently timeless atmosphere of academic research, is eliminated. The Diploma provides an ideal transition from the one type of discipline to the other, with the formal advanced teaching providing entry into the " pool of research " from the shallow end instead of the deep end. Moreover, the Diploma provides an important second opportunity for assessing a student's research potential. The man who has failed to do himself justice in the Honours examination is given another chance to prove his merit, while the man whose ability has been flattered by his degree result is now required to show a greater versatility of skills.

Entrance to the Diploma course is normally restricted to those who have obtained a 1st or 2nd class Honours degree or its equivalent. Experience has shown that less qualified students are unable to satisfy the Diploma requirements. It is hoped that in a relatively short time it will become the accepted custom for the majority of suitably qualified Honours graduates in physics to take a postgraduate course, such as that offered by the Diploma in Physics at Manchester. The initial experience and philosophy of the Manchester Diploma course were reported to the joint committee of The Institute of Physics and The Physical Society on *The Postgraduate Training of Physicists in British Universities*. It is gratifying to note that the course conforms closely to the recommendations of this committee in their report of March 1960.

# National Certificates in Applied Physics: 1960 Examinations

The rate of growth of the number of candidates for National Certificates in Applied Physics continues to be very satisfactory, as the following figures show.

| | *1954* | *1955* | *1956* | *1957* | *1958* | *1959* | *1960* |
|---|---|---|---|---|---|---|---|
| *Candidates for Higher Certificate* | 75 | 82 | 146 | 182 | 246 | 296 | 355 |
| *Candidates for Ordinary Certificate* | 206 | 309 | 424 | 456 | 637 | 820 | 914 |

Details of the 1960 results are given below. The certificates are awarded jointly by the Institute and Society and the Ministry of Education (or the Scottish Education Department) ; the Institute and Society is responsible, through its assessors, for the maintenance of the standard of the final examination. This year the assessors were :—

*England and Wales*

Physics - - - Professor J. D. Craggs
Applied Physics - Mr. A. E. De Barr
Mathematics - - Dr. J. Crank

*Scotland*

All three subjects - Dr. J. M. Valentine

Candidates who reach a sufficiently high standard in the examinations for the Higher National Certificate are given exemption from Part I of the Graduateship Examination ; the number of candidates securing such exemption is shown for each college.

In the following list, " Failures " includes a few candidates who were absent from the examinations.

Full details of courses for these certificates may be obtained from the Deputy Secretary.

| | **Ordinary National Certificate** | | | **Higher National Certificate** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Distinctions* | | | *Exemption* |
| *College* | *Candidates* | *Passes* | *Failures* | *Candidates* | *Passes* | *Failures* | *Physics* | *Applied Physics* | *Mathematics* | *from Part I* |
| (*a*) ENGLAND AND WALES | | | | | | | | | | |
| Acton: Brunel College of Technology ... ... | — | — | — | 10 | 7 | 3 | — | — | — | 1 |
| Bedford: Mander College ... ... ... | 11 | 7 | 4 | — | — | — | — | — | — | — |
| Birmingham College of Advanced Technology... | — | — | — | 24 | 17 | 7 | 2 | 1 | 4 | 4 |
| Birmingham: Matthew Boulton Technical College | 44 | 35 | 9 | — | — | — | — | — | — | — |
| Bournemouth Municipal College of Technology and Commerce ... ... ... ... | 20 | 11 | 9 | 9 | 7 | 2 | — | — | — | 2 |
| Brighton Technical College ... ... ... | 7 | 4 | 3 | 9 | 8 | 1 | — | — | 2 | 4 |
| Bristol Technical College ... ... ... | 15 | 11 | 4 | 6 | 4 | 2 | 1 | — | 1 | 2 |
| Cambridge: Cambridgeshire Technical College and School of Art ... ... ... ... | 15 | 15 | — | — | — | — | — | — | — | — |
| Cardiff: Llandaff Technical College ... ... | 2 | 2 | — | — | — | — | — | — | — | — |
| Cardigan Grammar School ... ... ... | 9 | 7 | 2 | — | — | — | — | — | — | — |
| Chelmsford: Mid-Essex Technical College and School of Art ... ... ... ... ... | 11 | 8 | 3 | — | — | — | — | — | — | — |
| Connah's Quay: Flintshire Technical College ... | 10 | 4 | 6 | — | — | — | — | — | — | — |
| Croydon Technical College ... ... ... | 23 | 20 | 3 | 14 | 9 | 5 | 1 | — | 1 | 3 |
| Crumlin: Technical College of Monmouthshire... | 14 | 11 | 3 | — | — | — | — | — | — | — |
| Derby and District College of Technology ... | 4 | 3 | 1 | 4 | 4 | — | — | — | 1 | 3 |
| Ewell County Technical College ... ... | 11 | 6 | 5 | — | — | — | — | — | — | — |
| Farnborough Technical College ... ... ... | 62 | 46 | 16 | 8 | 8 | — | 3 | — | 2 | 4 |
| Guildford County Technical College ... ... | 18 | 16 | 2 | 22 | 20 | 2 | 2 | 6 | 3 | 7 |
| Harrow Technical College and School of Art ... | 36 | 16 | 20 | — | — | — | — | — | — | — |
| Kettering Technical College ... ... ... | 7 | 6 | 1 | — | — | — | — | — | — | — |
| Kingston Technical College ... ... ... | 37 | 28 | 9 | 7 | 5 | 2 | 1 | 1 | — | 3 |
| Leeds College of Technology ... ... ... | 10 | 6 | 4 | 3 | 3 | — | — | — | — | 2 |
| Leicester College of Technology and Commerce | 12 | 10 | 2 | — | — | — | — | — | — | — |
| Letchworth: North Hertfordshire Technical College ... ... ... ... ... | 33 | 22 | 11 | 10 | 6 | 4 | — | — | 3 | 2 |
| Liverpool: College of Technology ... ... | 30 | 14 | 16 | 19 | 9 | 10 | — | — | — | 1 |
| London: Northampton College of Advanced Technology ... ... ... ... ... | — | — | — | 28 | 19 | 9 | — | 3 | 5 | 10 |
| South-East London Technical College ... | 81 | 31 | 50 | 30 | 17 | 13 | 2 | — | 4 | 9 |
| Northern Polytechnic ... ... ... ... | 29 | 22 | 7 | — | — | — | — | — | — | — |

| College | Candidates | Passes | Failures | Candidates | Passes | Failures | Distinctions: Physics | Distinctions: Applied Physics | Distinctions: Mathematics | Exemption from Part I |
|---|---|---|---|---|---|---|---|---|---|---|
| Newbury: South Berkshire College of Further Education | 62 | 38 | 24 | — | — | — | — | — | — | — |
| Newport and Monmouthshire College of Technology | — | — | — | 3 | 2 | 1 | — | — | — | — |
| Oxford College of Technology, Art and Commerce | 53 | 29 | 24 | 25 | 18 | 7 | 1 | — | 3 | 3 |
| Preston: Harris College | 11 | 7 | 4 | 6 | 4 | 2 | — | — | — | 2 |
| Reading Technical College | 37 | 26 | 11 | 26 | 13 | 13 | — | — | — | — |
| Rotherham College of Technology | 19 | 15 | 4 | 8 | 7 | 1 | 2 | 2 | 3 | 6 |
| Rugby College of Engineering Technology | — | — | — | 9 | 7 | 2 | — | — | — | 5 |
| Rugby, East Warwickshire College of Further Education | 17 | 11 | 6 | — | — | — | — | — | — | — |
| Salford: Peel Park Technical College | 23 | 13 | 10 | — | — | — | — | — | — | — |
| Salford: Royal Technical College | — | — | — | 10 | 2 | 8 | — | — | — | — |
| Salisbury and South Wilts College of Further Education | 3 | 1 | 2 | — | — | — | — | — | — | — |
| Southend-on-Sea Municipal College | 16 | 13 | 3 | 13 | 9 | 4 | — | — | 1 | 2 |
| Stafford: County Technical College | 11 | 8 | 3 | — | — | — | — | — | — | — |
| Stockport College of Further Education | 2 | 2 | — | — | — | — | — | — | — | — |
| Stoke-on-Trent: North Staffordshire Technical College | 8 | 1 | 7 | 5 | 1 | 4 | — | — | — | — |
| Sunderland Technical College | 30 | 16 | 14 | 10 | 6 | 4 | — | — | — | 1 |
| Swansea Technical College | 7 | 2 | 5 | 15 | 13 | 2 | — | — | 2 | 10 |
| Whitehaven College of Further Education | 12 | 7 | 5 | — | — | — | — | — | — | — |
| Worcester: College of Further Education, Victoria Institute | 9 | 7 | 2 | 5 | 4 | 1 | 1 | 1 | — | 1 |
| TOTAL | 871 | 557 | 314 | 338 | 229 | 109 | 16 | 14 | 35 | 87 |
| | [41 Colleges] | | | [27 Colleges] | | | | | | |
| (*b*) SCOTLAND | | | | | | | | | | |
| Aberdeen: Robert Gordon's Technical College | — | — | — | 3 | 3 | — | — | — | — | 1 |
| Thurso Technical College | 8 | 5 | 3‡ | — | — | — | — | — | — | — |
| Coatbridge Technical College | 5 | 4* | 1‡ | — | — | — | — | — | — | — |
| Dundee Technical College | 4 | 2* | 2 | — | — | — | — | — | — | — |
| Edinburgh: Heriot Watt College | 3 | 3 | — | — | — | — | — | — | — | — |
| Paisley Technical College | 23 | 11 | 12‡ | 14 | 14† | — | — | — | — | 6 |
| TOTAL | 43 | 25 | 18 | 17 | 17 | — | — | — | — | 7 |
| | [5 Colleges] | | | [2 Colleges] | | | | | | |
| GRAND TOTAL | 914 | 584 | 332 | 355 | 246 | 109 | 16 | 14 | 35 | 94 |
| | [46 Colleges] | | | [29 Colleges] | | | | | | |

* includes one candidate awarded certificate after being referred in one subject in 1959

† includes two candidates awarded certificates after being referred in one subject in 1959

‡ includes one candidate referred in one subject.

# News of Members

## FELLOWS

L. G. Carpenter has been promoted to be a Deputy Chief Scientific Officer at the Royal Aircraft Establishment, Farnborough.

W. D. Chesterman has been appointed Professor of Physics in the University of Hong Kong.

Sir John Cockcroft has received an Honorary Degree of Dalhousie University, Halifax, Nova Scotia.

J. H. Davis is now a Senior Lecturer at the Bradford Institute of Technology.

H. W. Emerton is Deputy Development Manager of the Paper and Board Division of Albert E. Reed & Co. Ltd., Maidstone, and Head of the Divisional Laboratory.

N. A. Esserman has been appointed Director of the Australian National Standards Laboratory and will retain the Headship of the Metrology Division.

Sir Willis Jackson is returning to Imperial College, London, as Professor of Electrical Engineering.

R. D. Lowde is now a Senior Principal Scientific Officer at the Atomic Energy Research Establishment, Harwell.

F. A. Vick is now Director of the Atomic Energy Research Establishment at Harwell.

## ASSOCIATES

R. A. Bembridge is an Assistant Lecturer at the Nuneaton Technical College and School of Art.

D. S. Briggs has been appointed a Physicist at the Windscale and Calder Works of the Atomic Energy Authority.

H. Burns has joined British Resin Products Ltd., Barry, Glamorgan, as a Research Physicist.

J. O. Clarke has become Physics Master at Oswestry High School for Boys.

D. G. Cole is with the Metallurgy Group of Associated Transistors Ltd., South Ruislip, Middlesex.

C. R. Coleman is in charge of the Physical Testing Laboratory of Monsanto Chemicals Ltd., Fulmer, Bucks.

O. H. Critchley is Senior Inspector, Inspectorate of Nuclear Installations, Ministry of Power.

I. K. Fisher has joined Holoplast Ltd., near Maidstone, Kent.

A. Garnham, referred to in the August 1960 *Bulletin* as a Senior Lecturer in Physics in the University of Durham, is Senior Lecturer in Physics at Bede College (a Teacher Training College), Durham.

A. Green is with the Research and Design Division of International Computers and Tabulators Ltd., Stevenage, Herts.

J. A. Hitchcock has been appointed a Group Leader at the Central Electricity Research Laboratories, Leatherhead.

P. W. Hoare is a Lecturer in Physics at Peterborough Technical College.

R. Hughes is now Physics Master at Rhyl Grammar School.

H. M. Iyer is a Post-doctoral Fellow at the Geophysical Institute, Scripps Institution of Oceanography, University of California.

A. M. Jessop is a Post-doctoral Fellow in the Department of Geophysics of the University of Western Ontario, Canada.

B. J. Kelly has been appointed Scientific Officer at the Culcheth Laboratories of the Atomic Energy Authority.

J. W. Midgley has been appointed Head of the Mechanical Physics Group of the Mechanical Engineering Laboratories of the English Electric Co. Ltd., Whetstone, Leicester.

K. N. Middleton is now Director of a Television Engineering Branch, Operation and Maintenance, Australian Broadcasting Commission.

P. N. Nikiforuk has been appointed Assistant Professor in the University of Saskatchewan, Canada.

A. F. Nicholson has joined Philips Electrical Industries Ltd., in Australia.

A. C. Pawson is now in Ghana as Training Director for Technical Education.

P. R. Pinnock has joined the Fibres Division of I.C.I. Ltd. of Harrogate.

A. G. Randell has been appointed Lecturer in Physics in the Portsmouth College of Technology.

E. I. Sherrard is with Mullard Magnetic Components at Southport, Lancashire.

W. A. Smith has joined the National Institute for Research in Nuclear Science, The Rutherford High Energy Laboratory, Harwell.

R. L. Spence has been appointed Senior Lecturer in Physics at the Leeds Day Training College.

D. Whittaker has been promoted Senior Scientist in the Mining Research Establishment of the National Coal Board.

W. M. Williams has been appointed Assistant Professor in the Department of Metallurgical Engineering of McGill University, Montreal.

W. Woodside is now Mathematics and Physics Master at Ridley College.

## GRADUATES

J. P. Bunn has been appointed a Lecturer in the Department of Applied Physics in the Lanchester College of Technology, Coventry.

R. B. Curtis is Head of the Physics Department at Gunnersbury Catholic Grammar School, London.

G. Derrick has been appointed an Assistant Professor in the Department of Mathematical Physics of the University of Manitoba, Canada.

G. W. Duck is now with English Electric Aviation Ltd., Stevenage.

N. T. Gallagher is the Sales Manager of the Metallurgy Division of Shandon Scientific Company Ltd., London.

J. Glazer is a Senior Electronic Engineer with J. F. Crosfield Ltd., London.

E. L. Holmes is a Research Associate in the Department of Metallurgical Engineering in the University of Toronto.

E. Mainwaring has joined the British Oxygen Company Ltd., London.

C. N. Owston is now a Lecturer in Physics in Leeds College of Technology.

R. Payne has been appointed Section Leader in the Armaments Division of Sir W. G. Armstrong Whitworth Aircraft Company Ltd., Coventry.

T. F. J. Quinn is now Assistant Lecturer in Brunel College of Technology.

F. Rainford is Head of the Physics Department of Berwick Grammar School.

R. D. Saunders has joined the English Electric Valve Co. Ltd., Chelmsford.

E. Whitten is now with the Admiralty Surface Weapons Establishment, Cobham, Hampshire.

# Appeal for the Physics Trust Fund

*The following donations or subscriptions were received between November 3 and 30:*

(*a*) From members

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The total received or promised by November 30 (including those previously announced) was:

| | £ |
|---|---|
| Gross value of industrial firms' covenants over seven years (including tax recoverable) ... ... ... ... ... ... ... | 61,509 |
| Single donations from firms ... ... ... ... ... ... ... | 3,464 |
| Total from Industry ... | 64,973 |
| Gross value of members' covenants over seven years (including tax recoverable) ... ... ... ... ... ... ... ... | 3,341 |
| Single donations from members ... ... ... ... ... ... | 323 |
| Total from members | 3,664 |
| GRAND TOTAL at November 30, 1960 | £68,637 |

# Reviews of Books

## THE ATMOSPHERE AND THE SEA IN MOTION—THE ROSSBY MEMORIAL VOLUME

**Edited by Bert Bolin**

*London: Oxford University Press. Pp. 509. Price 105s.*

This is a symposium with forty contributions by various authors on those branches of meteorology and oceanography which benefited in one way or another from Rossby's work. The diversity of the subjects covered is in itself an indication of the wonderful versatility and divergence of interest which C. G. Rossby had. All the authors have been personally connected with Rossby and come from centres where he had worked during his career—Bergen, Uppsala, Stockholm, the U.S. Weather Bureau, M.I.T., and the Universities of Chicago and California. This is presumably the reason why there is no British contributor.

The volume had originally been intended to be a sixtieth birthday appreciation volume, as Rossby would have been sixty on December 28, 1958, but he died on August 19, 1957. This is how the first chapter in the book, entitled "Current problems in Meteorology" was written by Rossby himself. It is a brilliant account of the present state of the subject and indeed it more or less summarizes the rest of the book.

I suppose it could be said that Rossby's more well-known contributions to these sciences are his leadership in the development of ideas on the general circulation of the atmosphere and the oceans. With the atmosphere, he was among the first to realize the importance of the "jet stream," that concentration of air currents between latitudes 30° and 50° at the border of the troposphere and stratosphere, at levels of the order of 300 to 100 mb. Similar features are present in oceanic circulation—The Gulf Stream in the Atlantic Ocean and the Kuroshio Current in the Pacific. Another feature of Rossby's work was his discovery of the long "waves," named after him, which encircle the globe in five or six wavelengths and which show up very clearly on 500 mb charts.

Perhaps the most important of Rossby's contributions will prove to be his guidance in the attempts now being made to carry out numerical forecasting. This was originally tried by L. F. Richardson in 1922 who attempted a twelve hour prognosis by a numerical solution of the appropriate differential equations but the problem is still too enormous to solve in its entirety even with modern computing facilities. Rossby, however, suggested certain simplifications which enabled an approximate solution at 500 mb to be obtained. This work has been extended to other levels since.

The contributions in the volume naturally cover all these topics. As an oceanographer, I may be excused if I concentrate more on the "The Sea in Motion" section where the influence of Rossby is also apparent. This consists of six contributions: J. Bjerknes, "The Recent Warming of the North Atlantic," B. Haurwitz, H. Stommel, and W. H. Munk, "On the Thermal Unrest in the Ocean," P. Welander, "On the Vertically Integrated Mass Transport in the Oceans," W. Hansen, "Wind und Massenverteilung als Ursache der Meeresstromungen," H. Wexler, "The Antarctic Convergence—or Divergence ?" and G. O. S. Arrhenius "Climatic Records on the Ocean Floor." The paper by J. Bjerknes describes the changes in mean temperature over the North Atlantic Ocean between the periods 1890-97 and 1926-33, and the increase in the Gulf Stream area during this time. This increase compares very well with the increase of atmospheric pressure at mean sea level for the same years which is associated with an increased anti-cyclonic circulation and stronger winds. It is concluded that the increasing temperature is caused by the increasing wind drag speeding up the Antilles Current and the Gulf Stream. The paper by Haurwitz, Stommel and Munk describes sea temperatures taken by thermistors at two points on the sea bottom at depths of 50m and 500m near Bermuda, during the period December, 1954, to October, 1955. Continuous records were taken with only one or two breaks and these are all reproduced. Although both records exhibit considerable "waviness," a detailed analysis shows that few of the apparent periodicities are significant all the time, although on occasions the semi-diurnal and diurnal periods and a period of 20 hr. appear to be so.

The paper by H. Wexler on "The Antarctic Convergence or Divergence ?" is very interesting though likely to be controversial. It has been held for some time that the Antarctic Convergence is due to the sinking of the warmer water due to converging currents so that colder Antarctic water comes to the surface causing a sharp discontinuity in sea surface temperature recordings on proceeding south through latitudes of about 70°S. Wexler's paper shows that the situation may be more complicated because there is a fine structure effect due to a narrow belt of cold water which is detached from, and north of, the main mass. He assumes this is caused by diverging sea surface currents letting the deeper colder water "upwell" to the surface. The prevailing winds are thought to cause this divergence in a similar manner to the effect caused on the coast of Southern California. This is quite a new point of view but as the observations of this narrow belt of cold water are confined to the month of December, 1956, and have not been confirmed by the observations of 1957, it will be necessary to do further work before drawing any conclusions.

There are twenty-one contributions under the heading "The General Circulation of the Atmosphere." There is a very interesting article by C. W. Newton on "Synoptic Comparisons of Jet Stream and Gulf Stream Systems." Rossby was one of the first to point out the remarkable similarity between the two systems and in this paper it is shown that there is a geometrical similarity of ratio 25 to 1 and a ratio of the velocities of the same order. This similarity still persists even when the fine structure of both systems is considered and the similarity between the meanders in each system is most striking.

Another interesting article is that by D. Fultz and R. Kaylor on "The Propagation of Frequency in Experimental Baroclinic Waves in a Rotating Annular Ring." This article describes further developments in what is usually called the "Chicago Dish-Pan Experiment." This is a model of the circulation of the atmosphere—a rotating cylinder is used and heated round the outside. Inside it is placed co-axially another copper cylinder containing water at a constant lower temperature. The base between the two cylinders consists of the surface of a cone, sloping inwards or outwards as desired. The space between the cylinders is filled with water. It can be shown that the latitude effect on the real Earth can be simulated by the variation of depth between the two cylinders and the movement of the water between the cylinders can be photographed and various features of the general circulation like Rossby waves can be reproduced. A similar model has been used by Von Arx to study oceanic circulation and some of the features of the Gulf Stream have been reproduced.

There is a section entitled "Weather Forecasting" consisting of five contributions. The first one is a historical account of the subject by T. Bergeron, a pioneer of the frontal idea of weather forecasting introduced in Norway towards the end of World War I. He describes the story from the early days of Admiral Fitzroy to the modern ideas of numerical forecasting by computer. Numerical forecasting is the subject of the next chapter by G. P. Cressman "Hemi-spheric Nondivergent Barotropic Forecasting." Examples are given of the 24hr, 48hr, 72hr, and 96hr forecasts of the 500 mb charts from 0000 November 3, 1957. There is in this case very good agreement but the forecasts naturally get less accurate as time goes on due to the neglect of such factors as skin friction and lateral eddy viscosity. The result is that the predicted isobars become too "straight."

There is also a section on the "Distribution of Matter in the Sea and Atmosphere," in which there are four contributions. One interesting subject is the distribution of Carbon Dioxide in the atmosphere. For the last hundred years, a hitherto unprecedented amount of $CO_2$ has entered the atmosphere due to the burning of fossil fuel. The question arises whether the $CO_2$ content of the atmosphere has increased accordingly. Callendar has worked out that there was an increase of 10 per cent since the beginning of this century, implying that very little of the gas entering the atmosphere would have been absorbed by the sea. More recent determinations have been made by measuring the Carbon 14 content of tree rings over many years. This should give an indication of the increase of $CO_2$ in the air due to fossil fuel as this contains no Carbon 14. From these measurements, Revelle and Suess concluded that the $CO_2$ only stays in the air about five years on the average before dissolving in the sea and that the increased content in the air is only a few per cent—much less than Callendar's estimate. In an article in this volume, Bolin and Erikson rather reverse the position as they consider that only the upper layer of the sea can absorb the $CO_2$ and this upper layer takes about 500 years to mix with the lower layer so that it soon gets saturated and on this basis they work out that the increase in $CO_2$ content by the year 2000 should be between 25 and 40 per cent. This result is of some practical importance as it has been shown by Plass that a doubling of the $CO_2$ content would lead to a rise in mean temperature of 3·6°C., although this estimate may need substantial modification.

In the introductory section there are two biographical accounts of Rossby's career. The first by Bergeron deals with his earlier years in Norway and Sweden. The second by Professor H. R. Byers of the University of Chicago deals with Rossby's career in America.

Considering the volume as a whole, I found it very readable and informative and its appearance at this time is very useful as a marker of the vast progress that has been made in these subjects during the last two decades.

J. Darbyshire.

## THE EXPLORATION OF THE SOLAR SYSTEM

**By Felix Godwin**

*London: Chapman and Hall, Ltd. Pp. 200. Price 35s.*

This is a fine example of the literary genre classified by a certain librarian as "non-fiction science fiction". Mr. Godwin discusses, with abundant detail, the construction of space ships for journeys to the moon, planets and stars. He goes on to design the laboratories and vehicles that will be used for scientific investigations when the travellers arrive. Naturally enough, a spirit of optimism pervades the book. Devices and processes still in the experimental or speculative stage on earth are freely used to solve the difficult problems of existence in space. Lunar rocks are heated to give steam and "electrolysis will then produce oxygen so that air and water problems are instantly solved". If carbon dioxide can be found somewhere, food and motor fuels can be manufactured. An electromagnetic accelerator, manufactured from local materials on the moon, is used to shoot sticks of solid hydrogen rocket fuel towards the earth.

The author, an industrious lad of 19 who is now studying physics at London University, has clearly read the literature of space travel very diligently. The book is an exercise of the imagination but the enthusiasm and clarity which it displays will be useful to Mr. Godwin if he decides to keep his feet on the ground in his subsequent scientific career.

J. M. A. Lenihan.

## PRINCIPLES OF OPTICAL CRYSTALLOGRAPHY

**By A. V. Shubnikov**

*New York: Consultants Bureau Enterprises, Inc. Pp. vi+186. Price $9·50.*

This book is a translation from the Russian, and it illustrates admirably the care and thoroughness that is being devoted in Russia to teaching the subject of the optical properties of crystals. It is not divided into normal chapters: the list of contents merely gives the headings of sections that are usually one or two pages in length; but certain general headings are also indicated.

These are as follows : the optics of isotropic media ; double refraction ; interference of light in crystal plates ; rotation of the plane of polarization ; elliptical polarization and elliptical double refraction ; and double absorption of light in crystals.

Students should find the book an excellent one for learning to understand the subject, for the author has spared no pains to try to clarify his explanations ; in fact, his approach sometimes may be considered laboured—as, for example, in his explanation of the role of the second Nicol prism for forming interference figures.

The book has, however, an important defect ; the author does not use standard symmetry nomenclature. Thus the point group $\bar{1}$ appears as $\bar{2}$, 2/m as 2:m and mm2 as m.2:m. There seems to be no justification for these symbols when there is international acceptance of the standard symbols, even in Russia.

It is a pity that this difficulty will make the book so much less useful as a students' textbook, because in most other respects it is admirable. Particularly attractive are the interference patterns (Figs. 83 and 85) presented as moiré patterns of intersecting ellipses and circles. Similarly much care has been devoted to the diagrammatic representation of three-dimensional surfaces. On the whole, I believe that the disadvantage of the symmetry nomenclature is more than offset by the clarity of the text, and I thoroughly recommend the book.

H. Lipson.

## THE EDGE OF OBJECTIVITY—AN ESSAY IN THE HISTORY OF SCIENTIFIC IDEAS

**By Charles Coulston Gillispie**

*London: Oxford University Press: Princeton University Press: Pp. 562. Price 42s.*

In the United States a determined effort is being made to bring the sciences and the humanities closer together. This book is written in what is becoming a tradition—a growing Corpus of information showing how mankind has struggled with Nature, at best to understand her, and at worst (sometimes) to force her to serve human ends. The course of events under review extends from Galileo to Maxwell, with a fore-view of Einstein a little off-stage. (If this much extension of time was considered permissible for field and cosmic physics, it is a little difficult to see why Carathéodory was not brought in to give the discussion on thermodynamics just that axiomatic touch for which it cries out). It is the subtitle " An Essay in the History of Scientific Ideas " which more truly represents the author's theme than the " Edge of Objectivity ", if only for the reason that, as the biographical essay declares, advances have been made by personalities more than by all the technicalities of science put together. So, in brief, thought reigns supreme, even though it was necessary to go through a very artificial period, beginning with the inveterate dualism occasioned by Descartes' separation of mind and matter. But Cartesianism, in one particular aspect, has done great things for physics, in marrying algebra to geometry, thus giving us the co-ordinare system—and even the notation itself—in daily use among many branches of elementary science. This is one amongst several examples where thought can be seen in the process of evolution, and thinking itself exhibits a kind of structure.

Perhaps the best piece of writing in the book (and the quality is a little variable) is the treatment of Francis Bacon (1561-1626). He was either a prophet or nothing. Living at exactly the right moment, his was a valuable contribution—and maybe the Royal Society would never have taken shape in the way it did without him. But his inductive methodology would in itself never lead to the discovery of anything: it was inherently incapable of doing so. To him knowledge was power, and not much else. His followers were to remain firmly on the runway, rather than to become air-borne. Nevertheless, sooner or later, science would perforce become an everyday affair, and he was the person who foresaw it.

The description of the Enlightenment and the *philosophes* is as true to-day as it is of a couple of centuries ago—the great gulf fixed between native French elegance and British factual accomplishment. Students of physics, when pondering over the phenomena of interference, cannot fail to notice the dichotomy, when they read of the researches of Fresnel and Thomas Young. Yet we do have our moments of formal beauty, as witness the indicatrix of Hamilton, with its explanation of internal and external conical refraction, not to mention the peculiar " dimples " of the tri-axial figure. This outstanding effort in prediction is omitted from what is in general a very able discourse on the development of the fundamentals of optics.

It is conceivable that, taking natural philosophy as a whole (as this volume rightly does), objectivity is declining as an intellectual virtue. If this is so—and signs in that direction are not wanting—Professor Gillispie's work may prove to be the last to evaluate in detail that particular characteristic of our mental equipment.

F. I. G. Rawlins.

## ATOMIC AND NUCLEAR PHYSICS

**By Robert S. Shankland**

*New York and London: The Macmillan Company. Pp. xvi + 665. Price 49s.*

The first edition of Professor Shankland's book was published in 1955; the text of the new edition is longer by 60 pages, and an impressive and extremely useful appendix of problems occupies a further 75 pages. Those familiar with the first edition will know that the emphasis is very much on the experimental aspects of the subject : derivations are few and far between, and there is little indication of the ways in which theory guides experiment and experiment restrains theory. Having so little to say about the evolution of ideas, this book does not compete as an introduction to modern physics with those by Born, and Wehr and Richards, but within his self-imposed limitations the author has written a splendid book. It is lively, lavishly illustrated with diagrams, line drawings and photographs, and the documentation is very complete, right from the 19th century beginnings of modern physics up to 1959. Experiments first reported in 1959 which are referred to or described include Crane's double-scattering experi-

ments with free electrons, Hoffman's work on stresses in thin metal films, Reines and Cowan's measurement of the proton-antineutrino cross-section, and Alvarez *et al*'s discovery of the $\bar{\Lambda}_0$ and $\bar{\Sigma}_0$ anti-hyperons. In certain places the revision of the text for the new edition includes some very skilful rewriting which has sharpened the sense.

Once or twice your reviewer felt that in the later chapters technology had taken precedence over physics. The chapter on " Nuclear energy sources ", which has been considerably enlarged in this edition, contains a great deal of information about the facilities available on different types of reactor, and even on specific reactors. In the preceding chapter on " Induced nuclear transformations " the section entitled " Neutron reactions " contains no information about the great volume of important work which has been done on neutron cross-sections, but is mainly concerned with a sequence of neutron-capture processes which occurred in a megaton thermonuclear explosion ; one hopes that the next generation is not being taught to regard this as a normal part of experimental technique.

Final year students should find this book useful, for its descriptions, problems and references are relevant to a large proportion of their work. And at 49s. it is first-rate value for money.

R. M. Sillitto.

## UNIVERSITY PHYSICS

**By F. C. Champion**

*London : Blackie and Son Ltd. Pp. 786. Price 30s.*

This volume collates the parts originally published separately over twenty years ago—General Physics, Heat, Light, Wave Motion and Sound, and Electricity and Magnetism. The first and fourth of these I always considered excellent, and the others good but perhaps unenterprising.

If this were an entirely new book, one would be inclined to criticize it in the terms so often used nowadays, that " it might have been written a long time ago ". Since it was, and has proved itself thoroughly in the meantime, one can only really take up matters of detail that might have been considered in the process of revision. There are several places, particularly in the Electricity and Magnetism section, in which the treatment and the diagrams might have been modernized. However, the difficulties of the elementary student do not alter with the years, and one cannot really ask for more than straightforward exposition, well-chosen examples, and helpful guidance in the solution of problems. " University " means first-year university work, or the second and third years of the sixth form at school; what I should call Advanced and Scholarship level, the author interprets precisely in terms of the London B.Sc. General Degree, and the publishers (who perhaps regard all southrons as English Nationalists) ascribe to Part I of the " National Sciences Tripos " at Cambridge.

G. R. Noakes.

## INFRARED RADIATION

**Henry L. Hackforth**

*McGraw-Hill Publishing Co. Ltd. Pp. vii + 303. Price 77s. 6d.*

This book was designed for use in college and university courses and for readers wanting to know more about infrared radiation in applied science. I do not think the author has achieved his aim, because he is a specialist in radiation problems in space, and his writing is the product of an unworldly point of view ; for example, among the detectors of infrared radiation he does not mention the human skin.

The author is also an expert in electronic engineering, to whom optics is a subsidiary subject ; and he writes on an American scale so that he can mention " a small tungsten filament lamp is run at 20-30 amp ".

For the European general reader the book is instructive, and illuminating, but it is not suitable for students, because of carelessness about details ; for example, on one page the usefulness of a thermocouple is said to be due to the variation in the resistance of the junction, although on the next page the output voltage is correctly attributed to the change in temperature. The diagram of a diffraction grating is misleading and the diagrams in general have been copied from other sources rather uncritically—one of them is upside down ! The bibliography includes about 170 references, nearly all from the western hemisphere, and a useful list of books, drawn from the whole world.

E. van Someren.

## TRAINING IN RADIOLOGICAL HEALTH AND SAFETY (Report of a Committee appointed by the United Kingdom Atomic Energy Authority)

*London: Her Majesty's Stationery Office, 1960. Pp. vi + 95. Price 5s. 6d.*

After the Windscale accident of October, 1957—and even before it—there were suggestions that the Industrial Group of the Atomic Energy Authority should give increased attention to the problems of health and safety affecting both their own employees and the general public. These views were endorsed by the Fleck Committee, who advised that steps should be taken as a matter of urgent national importance to enhance the supply of trained experts in radiological protection. The formulation of detailed proposals was entrusted to another committee, who have now produced an interesting report.

Their most important proposal is the establishment of a national radiological advisory service, incorporating the existing Radiological Protection Service of the Ministry of Health and the Medical Research Council. The new organization should have regional laboratories providing routine advice and monitoring services and perhaps engaging in research. Courses of systematic instruction, combined with research and leading to the M.Sc. or Ph.D. degree, should be instituted at a number of universities. Diploma courses should be given at colleges of advanced technology and background training should be organized for doctors, administrators and other professional groups.

For a variety of reasons, neither the Atomic Energy Authority nor the hospital service has been able to recruit and retain a sufficient number of first-class physicists and technologists to work in the field of health and safety. If the intellectual attractions were greater there would be no lack of candidates well qualified at the graduate or post-graduate level. Failing this, the Veale Committee's proposals for advanced training at various levels represent a realistic way of tackling the problem.

J. M. A. Lenihan.

## NUCLEAR ENGINEERING MONOGRAPHS — NUCLEAR REACTOR STABILITY

**By A. Hitchcock**

*London : Temple Press Ltd. Pp. ix + 61. Price 12s. 6d.*

It is a fundamental prerequisite of reactor design and operation that the power and power distribution of nuclear reactors can be controlled within fine limits. It must be possible to extract power at the desired rate without significantly affecting the physical properties of the materials of construction and the fuel elements. Since the rate at which the neutron reactions proceed and hence the power level, are determined both directly and indirectly by the power level itself (through changes in the number of nuclei, temperature, pressure, etc.), a problem of stability arises. It is necessary to determine in advance of reactor design and operation what form any instabilities might take and what kind of control system is necessary to deal with them.

Although the problem is a general one on which attention has been focused since the first reactors were designed nearly twenty years ago, a good deal of publicity has been given over the last few years to certain specific aspects. Examples are the instabilities arising in boiling water reactors (due to voidage instabilities) which lead to rapid " chugging " power fluctuations, the instability in power distribution (due to Xenon instability), observed in the Shippingport pressurized water reactor, and the instabilities expected to arise in the large Calder Hall type reactors as plutonium builds up in the fuel (due to Xenon and temperature instability).

This latest monograph in the Nuclear Engineering series provides a useful introduction to the study of reactor stability. The chapter on voidage instability is, however, brief and most of the monograph is concerned with Xenon and temperature instabilities. Examples are give for Calder Hall type reactors—a field in which the author has made many original contributions.

Factors affecting the reactivity (and hence stability) of the reactor, i.e. fuel and moderator temperatures and Xenon poison concentration, are discussed at the outset. Spatial effects are introduced into the linearized set of equations describing the system by means of eigenfunction expansions.

In the absence of coupling between these functions, simple stability criteria are obtained from the characteristic equations. In the direction of coolant flow the modes of the reactor are not known and coupling exists between the chosen eigenfunctions. Nevertheless, approximate stability criteria are obtained. In the final chapter, the author indicates how the stability analysis may be extended to include the presence of an automatic control system.

In short, the monograph may be recommended to all who are interested in a physical description of the processes governing reactor stability and the consequential control requirements, an elementary mathematical analysis and an indication of the limitations of this analysis.

J. G. Tyror.

## PHYSIQUE NUCLEAIRE

**By Michel Bayet**

*Paris : Masson et Cie. Pp. 404. Price 65 NF.*

This is essentially a text book based on other textbooks and in a subject that changes as rapidly as nuclear physics this is just not good enough. The author disarmingly reveals these secondary sources in the preface. They are the books by Evans, Halliday and Kaplan, all published five years ago. References to later books and papers are sparse indeed and seem to have been included as afterthoughts. Thus the fundamental paper of Lee and Yang on parity violation, written in 1956, is referred to in a brief introduction to the subject on p. 108, but the lengthy account of beta decay (pp. 183-205) is innocent of all knowledge of it. Incidentally, the reference to similar phenomena in biology is thoroughly misleading—Lee and Yang deal with $\Psi$, while biology deals with $|\Psi|^2$.

As a first introduction to the subject an absence of very recent developments is not perhaps such a serious matter, and that the author's aim is to provide a first introduction is shown by the fact that he includes chapters on classical and quantum statistics, relativity, kinetic theory of gases and old as well as new quantum theory. These occupy almost a third of the book, but even so can only be treated in the sketchiest of manners. Another third deals with the properties of nuclei and with radioactivity and the final section covers the properties of ionizing radiation and its detection, neutrons, nuclear reactions, fission and fusion. There is no mention of particle accelerators, but apart from this, nearly all relevant matter is included, although mostly there is so little of each item that it is difficult to see what the beginner can make of it all. The book is pleasantly produced, but the price is very high.

L. R. B. Elton.

## PROPERTIES OF DOUBLE STARS—A SURVEY OF PARALLAXES AND ORBITS

**By Leendert Binnendijk**

*U.S.A. : Pennsylvania University Press ; London : Oxford University Press. Pp. 349. Price 100s.*

The chapter on star pairs in ordinary textbooks of astronomy is tantalizing in its brief suggestion of vast physical problems. At the other extreme, we have the large treatise by Kopal (reviewed in *Bulletin*, Dec. 1959) which is written at research level presupposing a serious interest in such problems already aroused. The present work comes usefully between those extremes. In describing the instrumental techniques, photometric and

spectrophotometric, and the geometry and equations for extracting from observation the required parameters, this book is very thorough and shows a great wealth of excellent diagrams. Compared with that of Kopal it does not attempt anything like the rigour in dynamical account of why peculiarities occur as they are found in double stars. The two books are complementary, each providing more than the other in directions which might be called, perhaps, exploratory and explanatory respectively. The physicist to-day possesses in these two books an entry into binary star astronomy not available until last year ; he must first find how the facts are obtained, by reading Binnendijk, and then by reading Kopal approach the stirring question of how stars behave to one another in close company. On the latter, and the evolutionary problems which are some of the most exciting in modern astrophysics, Binnendijk ventures little.

The price of the two books is almost identical ; the size of Binnendijk smaller by number and size of pages, but probably much money as well as much care was lavished on his very shrewd diagrams. One would have liked something comparable to the historical and biographical notes which neatly and sometimes humorously lightened the tremendous weight of learning in Kopal.

MARTIN JOHNSON.

## HISTOLOGICAL TECHNIQUES FOR ELECTRON MICROSCOPY

**By Daniel C. Pease**

*New York and London: Academic Press Inc. Pp. xii + 274. Price $7.50.*

Dr. Pease is to be congratulated on producing the first handbook to describe in full the procedures for preparing biological tissues for examination in the electron microscope. At a time when an increasing number of biological laboratories are acquiring electron microscopes and are starting to study the fine structure of cells, such a book is a necessary and valuable introduction to the subject. Although techniques are continually being modified and improved, and new techniques devised, there is a great advantage in having the methods which have already proved successful clearly described in one book.

Dr. Pease is exceptionally well qualified to present this subject. In collaboration with Dr. R. F. Baker he was one of the first to cut thin sections of biological material in 1948, and since that time he has remained in the forefront of technical advances in the field. In consequence he is able to present each technique with its proper historical background and thus give the beginner a feeling for the development of the subject as a whole.

The routine procedures that are used in Dr. Pease's laboratory are described in detail from the initial selection and fixation of the specimen to the final evaluation and interpretation of the electron micrographs. Thus the book gives a completely satisfactory description of the handling of the type of specimen with which Dr. Pease is most familiar (mammalian tissues of all kinds). Perhaps the chief omission is a sufficient description of the necessary modifications to the standard procedures for the study of thin sections of other types of specimen, such as botanical material, protozoa and bacteria. Very wisely Dr. Pease has decided not to attempt to describe techniques with which he is not familiar, but the book would be more complete if reference were made to the more important modifications that are required in the study of these other types of specimen.

Each stage in the production of thin sections, their examination in the microscope and their photographic recording is lucidly described, and most workers will agree with Dr. Pease's assessment of the relative merits of the various techniques. The chapter on photography is particularly useful. Minor criticisms may be made of Dr. Pease's recommendations for making glass knives. It is surprising to learn that edge trimmings from a glazing company have sufficiently good edges for making glass knives, and some workers have found that as little torque as possible should be applied to the glass strips during the final break to make the cutting edge of the knife.

In a final chapter Dr. Pease describes methods for studying unsectioned material, and gives a description of replica techniques and the shadowing of particulate material with heavy metals. No mention is made of the " negative contrast " methods developed by Brenner and Horne, which have recently made possible a remarkable advance in studies on the structure of viruses, and it is hoped that they will be included in the next edition of this admirable handbook.

AUDREY M. GLAUERT.

## HIGH FREQUENCY APPLICATIONS OF FERRITES

**By J. Roberts**

*London : The English Universities Press Ltd. Pp. x + 166. Price 16s.*

This work is one of a series written for advanced undergraduate, postgraduate and research workers. The editor of the series makes it clear in his general foreword that he has particularly postgraduate students in mind. The book should be especially suitable for electrical engineering students.

There is firstly a general descriptive treatment of the fundamental properties, crystal structure, etc., of ferrites which have the formula $MFe_2O_4$, of which $Fe_3O_4$ is a special case and M is a divalent metallic atom, e.g. Ni. " Barium ferrite ", $BaO.6Fe_2O_3$ is another special case treated also in the book in a separate chapter. The section on wave propagation in magnetized ferrites is properly analytical and indeed the whole treatment of microwave devices is excellent. There are also good chapters on ferrites with rectangular hysteresis loops, including material on matrix storage, etc., and on inductor and transformer cores.

This seems to be the first book of its kind specially written on the subject and as an authoritative but necessarily limited treatment (at the price) it is to be specially recommended.

J. D. CRAGGS.

## ANALOGUE AND DIGITAL COMPUTERS

**Edited by A. C. D. Haley and W. E. Scott**

*London : George Newnes Ltd. Pp. viii + 308. Price 50s.*

This book consists of ten chapters written by seven authors. A general introductory chapter on both analogue and digital computers is followed by three chapters giving details of analogue computing circuits and, to a limited extent, examples of the application of these machines to practical problems. A few examples treated in greater detail would have been more welcome. The remaining five chapters are concerned with the basic circuitry of digital computers and to a much lesser extent with programming a hypothetical machine.

The main criticisms of this book as mentioned in the preface are that a certain amount of overlapping occurs amongst the different chapters and to some extent the treatment is out of date. These are inevitable consequences of an attempt to produce an up-to-date summary by several authors of a rapidly-developing subject. The book is intended for newcomers to the subject but parts of it will make difficult reading except for those with some basic training in electronics.

C. C. Ritchie.

## AN INTRODUCTION TO LINEAR PROGRAMMING AND THE THEORY OF GAMES

**By S. Vajda**

*London : Methuen & Co. Ltd. Pp. 76. Price 9s. 6d.*

The name "operational research" came into use during World War II to describe the activities of teams formed of scientists from a variety of disciplines, in applying scientific methods to the solution of various problems which arose in the conduct of the war. The name has since become more specifically applied to the new branch of science which is concerned with analysing data on which the correctness of future actions depends, and with condensing and presenting them in such a way that those with managerial authority can base their decisions on them.

It is clearly desirable that physicists likely to be concerned with the management side of industry should have some knowledge of the scope and possibilities of this new discipline.

Operational research uses a variety of mathematical techniques, and this little book gives a short introduction to two of them. Based on courses of ten to twelve lectures to various audiences, it can be read almost in an evening, the mathematics involved being quite elementary.

In each of the two sections, the scope of the subject is indicated by simple examples. In part I on Linear Programming, one of the problems discussed is the Transportation Problem, that of finding the most economical way of distributing a product from several sources of supply to other localities of use. Among the earliest problems in the history of linear Programming, this has been described as one of the most-solved problems, so many methods having been devised for its solution. Graphical representation, the simplex method and the concept of duality are discussed. The fundamental theorem of duality is proved in an appendix.

Part II proceeds on the same lines, working from simple examples to more general ideas. Altogether this book gives a very readable introduction to its two subjects, and it can be recommended to anyone wishing to learn something about these topics without going into them very deeply.

A. W. Gillies.

## PROGRESS IN AUTOMATION—Volume I

**Edited by A. D. Booth**

*London : Butterworths Scientific Publications. Pp. viii + 231. Price 42s.*

This book contains articles by eleven different authors on various topics which can be regarded as being connected in some way by the concept of "automation". These vary from analogue-digital conversion through machine-tool control to nucleonic gauges and automatic inspection.

Limitations of space ensure that even nominally general articles soon concentrate on a particular example most familiar to the author, and notwithstanding this there is considerable duplication when authors on related topics set out general requirements for similar or identical applications.

Much of the material is available in brochures or articles in periodicals. Failing a more organized and integrated assembly, this might be thought to have sufficed.

T. H. O'Beirne.

## TEACH YOURSELF ATOMIC PHYSICS

**By J. M. Valentine**

*London: The English Universities Press Ltd. Pp. 192. Price 7s. 6d.*

This small book is intended for the home student and for those who wish to obtain an introduction to atomic physics, and in this sense I suppose we are all included. There are only a few pages on (extra nuclear) atomic physics ; the rest is on nuclear physics.

The work is well written and reasonably self-contained except in places, for instance on page 85 where there is some material which will not be *a priori* familiar to the average non-scientist. A certain elementary knowledge of kinetic theory is assumed, or at least taken for granted, and it is clear that before teaching yourself atomic physics you have to teach yourself "physics and mechanics". It would be interesting to try this book on arts students who are, we hope, becoming increasingly exposed to scientific matters and the general process of enlightenment about our natural world. The present book should be excellent for sixth form students and intermediate, i.e. first year physics and engineering students at universities, besides those in a similar position at colleges of technology.

There is an introductory chapter on general atomics including that ultimate horror, the discharge tube. Then there are chapters on electronic structure of atoms, nuclei, particle accelerators, detecting and measuring instruments, nuclear reactors, nuclear reactions, nuclear weapons, industrial uses of reactors and radioactive isotopes, and finally the medical and biological uses of radioactive isotopes. The later chapters are very well done and very readable.

J. D. Craggs.

# Forthcoming Institute and Society Meetings

| *Date* | *Place* | *Speaker* | *Title and other details* | *Time* | *Branch or Group* |
|---|---|---|---|---|---|
| Dec. 15 | **London**<br>Imperial College | Dr. C. G. Wynne<br>(*Imperial College, London*)<br>Mr. R. W. Uffen<br>(*Imperial College, London*) | **A flat field microscope objective**<br>**The field for fibre optics** | 2.30 p.m. | Optical |
| Dec. 15 | **Aberdeen**<br>The University | Dr. N. E. Cusack<br>(*Birkbeck College, London*) | **Some electrical properties of molten metals** | 7.45 p.m. | Scottish |
| Dec. 15 | **London**<br>Imperial College | Dr. R. W. B. Stephens, F.Inst.P.<br>(*Imperial College, London*)<br>Mr. W. Llowarch<br>(*Ministry of Education*) | Discussion meeting on<br>**Demonstrations and laboratory work in the teaching of acoustics** | 5.30 p.m. | Acoustics |
| Dec. 16 | **Swansea**<br>University College | Dr. N. Kurti, F.Inst.P., F.R.S.<br>(*Clarendon Laboratory, Oxford*) | Branch Annual General Meeting followed by a lecture on<br>**Recent developments in the millidegree and microdegree absolute temperature range** | 5.15 p.m. | South Wales |
| Dec. 19 and 20 | **London**<br>Queen Mary College | | Conference on<br>**Statistical Mechanics** (with special reference to irreversible processes)<br>Registration for this conference is necessary. | | |
| Jan. 10 to 12 | **Bristol**<br>The University | | Conference on<br>**The physics of polymers**<br>Registration for this conference is necessary and application forms are available from The Programs Secretary | | |
| Jan. 11 | **London**<br>Headquarters | Professor R. E. Peierls, C.B.E., F.R.S.<br>(*University of Birmingham*) | **Teaching mathematical physics** | 5.30 p.m. | Education |
| Jan. 12 | **Liverpool**<br>The University | Mr. S. Rees Jones<br>(*Courtauld Institute of Art, London*) | **Physics and painting** | 7.00 p.m. | Liverpool and North Wales |
| Jan. 13 | **London**<br>" Horseshoe Hotel " | Mr. Thorold G. Jones<br>(*Atomic Energy Research Establishment, Harwell*) | Dinner meeting followed by an informal address on<br>**Gem stones**<br>Registration is necessary. Full details will be sent to Group members | | Non-Destructive Testing |
| Jan. 16 | **Manchester**<br>College of Science and Technology | Dr. J. M. A. Lenihan, F.Inst.P.<br>(*Western Regional Hospital Board, Glasgow*) | **Physics and physic** | 7.00 p.m. | Manchester and District |
| Jan. 16 | **Edinburgh**<br>The University | Mr. C. A. Taylor, F Inst.P.<br>(*College of Science and Technology, Manchester*) | **Optical transform techniques** | 7.15 p.m. | Scottish |
| Jan. 16 to 20 | **London**<br>Royal Horticultural Society's Halls | | 45th Exhibition of scientific instruments and apparatus<br>Admission is by ticket only available from The Secretary. | | |
| | | Mr. F. S. Burt, 17<br>Dr. G. E. R. Deacon, 18<br>Dr. F. P. Bowden, 19 | **Hydrodynamic research**<br>**Physics of the oceans**<br>**Some physical problems in travelling at supersonic speed** | | |
| Jan. 17 | **Glasgow**<br>The University | Mr. C. A. Taylor, F.Inst.P.<br>(*College of Science and Technology Manchester*) | **Optical transform techniques** | 7.15 p.m. | Scottish |
| Jan. 17 | **London**<br>Headquarters | Professor G. W. Hutchinson<br>(*University of Southampton*) | **Some recent developments in particle detectors** | 5.30 p.m. | Electronics |
| Jan. 18 | **Dundee**<br>Queen's College | Mr. C. A. Taylor, F.Inst.P.<br>(*College of Science and Technology, Manchester*) | **Optical transform techniques** | 5.30 p.m. | Scottish |
| Jan. 18 | **Birmingham**<br>Dunlops Ltd. | | Visit to factory and laboratories, Dunlops Ltd., followed by a talk<br>Registration is necessary. Full details will be sent to Group members | 2.00 p.m. | Midland |
| Jan. 18 | **London**<br>Headquarters | Dr. R. W. Hill<br>(*Clarendon Laboratory, Oxford*) | Group Annual General Meeting followed by a lecture on<br>**The thermodynamic properties of fluid helium** | 4.00 p.m. | Low Temperature |
| Jan. 18 | **London**<br>Royal Horticultural Hall | Mr. D. W. Robinson<br>(*National Physical Laboratory, Teddington*)<br>Miss S. Fogarty<br>(*Ministry of Transport*) | Symposium on **Traffic noise** | 2.00 p.m. | Acoustics |

| *Date* | *Place* | *Speaker* | *Title and other details* | *Time* | *Branch or Group* |
|---|---|---|---|---|---|
| Jan. 20 | **Newport** Newport and Monmouthshire College of Technology | Dr. A. P. Willmore (*University College, London*) | **Astronomical observations from rockets and satellites** | 6.15 p.m. | South Wales |
| Jan. 20 | **Bristol** College of Science and Technology | Mr. G. W. Warren, M.B.E., F.Inst.P. (*Research Laboratories of the General Electric Co. Ltd., Wembley*) | **The physicist and the technologist in industry** | 7.00 p.m. | South Western |
| Jan. 23 | **London** Headquarters | Dr. E. Eastwood (*Marconi Research Laboratories, Great Baddow, Essex*) | **Some new applications of radar** | 6.00 p.m. | London and Home Counties |
| Jan. 25 | **Durham** Science Laboratories | Dr. E. Mendoza (*University of Manchester*) | **Superconducting circuitry** | 5.30 p.m. | North Eastern |

# The Journals

## PRINCIPAL CONTENTS OF THE DECEMBER, 1960, ISSUES

### *British Journal of Applied Physics:* Volume 11, No. 12

**Summarized proceedings of a conference on applied spectroscopy—Seascale, June 1960.**

The Summer Conference of the Applied Spectroscopy Group of The Institute of Physics was held at the Windscale Club, Seascale, near the United Kingdom Atomic Energy Authority Works, on June 16 and 17, 1960. About fifty members of the group assembled at this conference, and the papers presented, together with the ensuing discussion, are summarized below. Among the topics discussed were the Mössbauer effect, the chemical and isotopic analyses of radioactive materials by spectroscopic and radioactivation techniques, the use of spectroscopy in determination of discharge temperatures and the development of monitoring systems for beryllium determination.

**Deposition of *Lycopodium* spores upon glass slides exposed in a wind tunnel.** By C. N. Davies, F.Inst.P.

An analysis, based upon experimental data, is made of aerodynamic factors concerned in the deposition of *Lycopodium* spores upon glass microscope slides exposed at various angles in a wind tunnel. Gravity controls deposition on horizontal slides only at low wind speeds ; with increasing speed impingement upon the leading edge of a microscope slide prevents deposition from taking place on the upper surface At sufficiently high wind velocities deposition takes place by eddy impaction, originating from turbulence in the main air stream, upon the upper and lower surfaces. Deposition on the lee side of bluff obstacles by eddy impacation is discussed.

**Some remarks on the conduction current in insulating liquids.** By K. Sugita.

The influence of gases, absorbed in liquids and adsorbed on the surface of electrodes, upon the current conduction in insulating liquids was investigated. At field strengths up to $10^5$ V/cm, the current depends upon the gases adsorbed on the electrode surfaces as well as on those absorbed in the liquid. Based upon the experimental results obtained in uniform and non-uniform fields, the hypothesis that carriers are supplied from the anode in liquids is discussed in relation to the gas-adsorbing power of the metals used as electrodes. It is believed that if the electrodes are not degassed, the conduction currents are governed not only by negative carriers from the cathode but also by positive ones formed at the anode.

**Comparison of X-ray and nuclear magnetic resonance measurements of crystallinity in polyethylene terephthalate.** By G. Farrow and I. M. Ward.

X-ray and nuclear magnetic resonance (n.m.r.) measurements of crystallinity have been made over a wide temperature range on oriented and unoriented samples of polyethylene terephthalate. The results show that, although in general terms, no correlation exists between the two methods, above the glass transition a considerable proportion of the non-crystalline regions achieve molecular mobility. The n.m.r. method gives higher values of crystallinity than the X-ray method. This is apparently due to some of the non-crystalline material being immobilized owing to entanglements, and the presence of surrounding crystallites for this material will make a contribution to the broad component of the n.m.r. signal which is used as a measure of the crystalline fraction of the polymer.

**Image formation by electron bombardment of metal targets.** By E. H. Hirsch.

In a demountable vacuum system a latent image is formed of a region on a metal target which has been subjected to very weak electron bombardment. This image can be made visible by electroplating the target in a copper sulphate solution. An experimental investigation of the influence of bombarding current, electron energy and target temperature is presented. The results suggest that the effect is due to the formation of a monolayer of hydrocarbon contamination, the build-up of which is catalytically accelerated by the metal target. The effect takes place even with 5 V electrons and can be used to obtain permanent visual records of slow electron beam focal spots.

**Measurement of hardness at very high temperatures.**

By L. M. Fitzgerald.

A new method of determining hardness at high temperatures has been developed and is being used, particularly, to study materials having melting-points in the region of 3000°C. The principle of the hardness measurement is the determination of the height of rebound of a spherical indenter. Tungsten-carbide balls of diameter $\frac{1}{8}$ in. are dropped on to the specimen from a height of about 22 in. The method of measurement makes use of a photomultiplier tube and an electronic timing device. A graphite-tube resistance-heated furnace is used to obtain the temperatures required. The furnace chamber and measuring apparatus is maintained at a vacuum of 0·1 $\mu$ ($10^{-4}$ mm of mercury) and is also surrounded by a water-cooling jacket. The plastic deformation of hard carbides as the temperature is increased has been measured with this apparatus. Some typical results are given.

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## *Journal of Scientific Instruments:* Volume 37, No. 12

**Further experiences with aluminium wire seals for bakeable vacuum systems.** By L. Elsworth, L. Holland, F.Inst.P., and L. Laurenson.

The use of aluminium *cemented* seals in vacuum systems has been further investigated to find the effect of the flange surface finish on the adhesion of the aluminium joint and the performance of such seals in bakeable apparatus. Aluminium wire clamped between stainless-steel flanges and baked at 300°C formed more adherent joints as the surface finish was decreased from 50 to 10 $\mu$ in. (average height of asperities). The aluminium joint would not cold weld with a force of 4 tons per inch of 20 s.w.g. wire using flanges with a surface finish of 10 $\mu$ in., and the flanges were indented by the wire. With constant surface finishes, the strength of the aluminium joint was directly proportional to the baking temperature above a forming temperature (250°C at 10 $\mu$ in.) and was greatest when the aluminium wire was perpendicular to the direction of the machining marks. Seals made between flanges with a 10 $\mu$ in. finish had an adhesion strength of 354 lb/in. of wire after forming with a force of 5,000 lb per inch of wire and baking at 400°C. Vacuum seals using a total length of 9 ft of wire were successfully employed in a stainless-steel vacuum plant with a 28 litre volume chamber. The plant was exhausted by an oil diffusion pump (baffled speed 40 l./s) with a liquid nitrogen trap and gave an ultimate pressure of $7 \times 10^{-10}$ mm of mercury, and $10^{-10}$ mm of mercury using a titanium evaporated getter. The seals had to be uniformly heated to avoid unequal expansion breaking the " cemented " joints.

**Wide-angle photoelectric integrating flashmeter.** By J. Edwards, W. R. Lane, F.Inst.P., and B. R. D. Stone.

The design, construction and calibration of a compact portable battery-operated photoelectric integrating photometer, which was developed for measuring very low levels of luminous energy incident on a surface from a distant light flash at night, is described. The instrument has a linear response and on its most sensitive range gives full-scale deflexion for an exposure of 0·004 lx s. Drift, arising from the photocell dark current and night-sky background illumination, is neutralized by feeding into the integrating capacitor a variable compensating current. Six ranges of sensitivity are provided, and colour filters can be inserted for measurements in restricted wavebands.

**Portable water velocity meter.** By J. M. Edington and L. Molyneux.

Wilkie has described an instrument for measuring the velocity of water, in which the rate of rotation of a small polystyrene rotor is measured by electronic means, using valves as the active circuit elements. The present paper describes a circuit in which the valves are replaced by transistors and which is designed so that compensation for changes in the conductivity of the water occurs automatically. As the instrument is small and light and powered by a self-contained battery it is particularly suitable for field work.

**Swept Langmuir probe system for intense gas discharges.** By H. W. Jones and P. A. H. Saunders.

The apparatus described provides a pulse of biasing voltage to a probe system so that electron temperatures up to $2 \times 10^5$°K and ion densities up to $5 \times 10^{14}$/cc can be measured. The system consists of a low impedance voltage sweep generator, a transformer-coupled measuring circuit and a logarithmic amplifier. The apparatus can be used to sample a portion or the whole of the electron energy distribution by using double probes of equal or greatly unequal areas. The probe plots are displayed directly on an oscilloscope.

**Photomultiplier soft X-ray spectrometer.** By L. Jacob, R. Noble and H. Yee.

A description is given of a soft X-ray spectrometer which uses a Be–Cu photomultiplier as detector. Unlike most spectrometers of this type it is not a modification of a previously existing photographic instrument, but was designed specifically to take advantage of the new technique. In particular the photo-detector is made to move around the Rowland circle by the simple expedient of mounting it on a radial arm. Its method of use is described and the emission band spectra of Al, Mg, Na and Li are given as examples of results obtained with it.

**Stability of some reactance standards.** By L. H. Ford.

Examples are given of the behaviour over several years of the working standards of inductance and capacitance maintained at the National Physical Laboratory. The information is supplementary to that contained in previous papers.

**Monitor for the quantitative determination of beryllium in the atmosphere.** By M. S. W. Webb, R. J. Webb and P. C. Wildy.

The air is drawn through a triggered intermittent arc and the intensity of the beryllium doublet at 3130Å is monitored, together with the adjacent background, and the ratio of these intensities is recorded on a ratio recorder. Provision is made for frequent calibration by means of an aerosol of known concentration, produced by an auxiliary spark between beryllium-copper electrodes. The accuracy and sensitivity of the instrument are not materially affected by the chemical form of the beryllium, and are unaffected by the sizes of particles normally encountered in atmospheric dust. The instrument is mobile, fully automatic and rapid in operation, one result being produced each minute. The limit of detection is 1 $\mu g/m^3$ for a twenty-second sampling time. The instrument is considered to have potentialities for the determination of other elements in air, apart from beryllium.

**Vibrating reed magnetometer.** By D. C. Doughty and P. Mossman, Grad.Inst.P.

This instrument is a development of the pendulum magnetometer for the measurement of saturation magnetization: it has been found especially useful for exploratory work on new materials, since the test samples it requires are small and of simple shape.

The specimen is attached to the end of a flat non-magnetic spring, maintained in continuous vibration in a non-uniform magnetic field: by observing the resonant frequency with and without the field, the magnetization can be calculated by comparison with a reference sample. Accuracies of about 1% can be obtained on materials with specific magnetizations of 50 e.m.u., while the lower limit of usefulness of the instrument is determined primarily by the accuracy required. The device is robust, inexpensive to construct and, in its present form, may be used from room temperature up to 400°C.

**Geiger counter backgrounds.** By B. L. Cohen.

An extensive study of counting backgrounds in ten essentially identical Geiger counters is reported. Important long-term time variations were found; their rate is generally less than $\frac{1}{4}$% per day, they change direction frequently and their total magnitude averages about 6%. They could not be correlated with counter efficiency, and were not, in general, correlated among the different counters. Consecutive day differences were generally less than 1%, although about 20% of the time there were non-statistical variations in the same direction in all counters, averaging 2·3% in magnitude. No day-night variations were detected within an accuracy of one part in 300. Temperature effects were found to be extremely important. An experience with an area-wide air contamination is discussed.

**Temperature-control system for use with a spectrophotometer.** By S. W. Thorne.

A scheme is outlined for the accurate control of the temperature of a standard 5 cm cuvette and contents. Any temperature over, for example, a range of 30–80°C may be selected to an accuracy of ±0·1°C with a subsequent control variation of the order of ±0·05°C. A check-point and interpolation method is described to achieve this selection accuracy. An electromagnetic method designed to provide remote stirring is indicated.

**Viscometers having damped torsional oscillation.** By B. S. Ashwin, T. Hagyard, I. C. B. Saunders, and T. E. Young.

Two types of torsional pendulum viscometers, having only one solid-fluid boundary, have been developed specifically for use in fluidized solids investigations. They may have utility also in coarse or fibrous suspensions or in melts at high temperatures. The theory of these viscometers is discussed and empirical correlations are presented whereby any instrument of these two types may be used with minimal or no calibration.

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## Papers accepted for publication in *Proceedings of The Physical Society*

**An investigation of some (t,d) reactions in light nuclei at 5·5 MeV.** By F. de S. Barros, P. D. Forsyth, A. A. Jaffe and I. J. Taylor.

A broad range magnetic spectrograph has been used to analyse the deuterons emitted from targets of natural boron, carbon, silicon dioxide and aluminium bombarded with 5·5 MeV tritons. The angular distributions of the majority of the deuteron groups from the reactions observed in $^{10}$B, $^{12}$C, $^{13}$C, $^{16}$O, $^{27}$Al and $^{28}$Si have been measured and information has also been obtained on (t,d) reactions in $^{24}$Mg, $^{28}$Si, and $^{40}$Ca because of the presence of these nuclei as impurities in the targets. In all cases the measured excitation-energies of the final nuclei are in good agreement with the accepted values. The angular distributions have been compared with the stripping theory and also with published data on (d,p) transitions between the same initial and final nuclear states. Where possible the ratios of the yields of corresponding (t,d) and (d,p) reactions have been compared with the predictions of stripping theory to extract values of the proportionality constant of the momentum transform of the deuteron within the tritron, $|A_0|^2$ Ni$^3$. The values obtained vary between $1{\cdot}8{\cdot}0 \times 10^{12}$ cm$^{-3}$ for the transition from $^{10}$B to the ground state of $^{11}$B and $1{\cdot}3 \times 10^{12}$ cm$^{-3}$ for the transitions from $^{16}$O to the ground state of $^{17}$O and from $^{28}$Si to the 3·630 MeV excited state of $^{29}$Si.

At 5·5 MeV triton bombarding energy, therefore, a constant value of $|A_0|^2$ Ni$^2$ cannot be used to extract values of nucleon reduced widths from studies of (t,d) reactions.

**The electrical resistivities and magnetic susceptibilities of some stable and metastable uranium-molybdenum alloys.** By L. F. Bates and R. D. Barnard.

The magnetic susceptibilities and electrical resistivities of a series of quenched $\gamma$ b.c.c. uranium-molybdenum alloys were measured over the temperature ranges 293-1200°K and 90-1200°K, respectively. U-15, 20, 25 at.% Mo each possessed a small negative temperature coefficient of resistivity below and slightly above room temperature in the metastable $\gamma$ state, and a positive coefficient in the stable $\gamma$ region.

All samples exhibited a Pauli weak spin paramagnetism which increased with temperature, and in addition possessed an exchange contribution shown to be independent of composition over the range 15-30 at.% Mo. The bearing of the results on our understanding of the electronic structure of the $\gamma$ alloys is discussed.

**A scanning instrument for the measurement of optical frequency response.** By K. G. Birch.

The instrument described measures alternatively the distribution of intensity in the image of a narrow slit (the spread function), or the frequency response function, which latter is the Fourier transform of the spread function. For the former use a slow scan with an exploring slit is used while for the direct determination of the frequency response curve a continuous scanning with a grating of slits arranged around the periphery of a variable speed drum is employed with a single frequency electrical detector.

The in-focus aberration-free image of a line source has been measured together with the axial variation of central intensity and good agreement with the theoretical curves has been obtained. The frequency response curves obtained by taking the Fourier transforms of four out-of-focus spread functions numerically agree well with the direct determinations of the frequency response with the scanning drum. Further, the frequency response curves for a well corrected lens in different focal planes have been compared with results obtained by Hopkins theoretically.

**Energy transfer in organic systems. III—Solute-solute transfer in liquid solutions.** By J. B. Birks and K. N. Kuchela.

Solute-solute intermolecular energy transfer has been studied in the ternary solution system toluene-TP (*p*-terphenyl)-TPB (1,1′, 4,4′-tetraphenylbutadiene) with a TP concentration of $2{\cdot}17 \times 10^{-2}$M, and TPB concentrations from $1{\cdot}5 \times 10^{-6}$M to $6 \times 10^{-3}$M, using excitation wavelengths from 285 m$\mu$ to 365 m$\mu$.

The behaviour is described quantitatively by competition between radiative transfer, which predominates up to $10^{-4}$M, and non-radiative dipole-dipole transfer, which becomes important at higher concentrations. The observed radiative transfer agrees with that predicted from the TPB absorption and emission spectra, and depends on the solution thickness. The observed dipole-dipole transfer corresponds to a critical transfer distance $R_0 = 42{\cdot}2$Å, compared with a theoretical value of $R_0 = 42{\cdot}5$Å, indicating that molecular diffusion and TP excitation migration have a negligible influence on the transfer process, which is single-step.

The bearing of the results on the choice and design of organic scintillator systems is briefly discussed.

**One-dimensional chains with random spacing between atoms.** By R. E. Borland.

The calculation of the integrated density of states for positive electron energies, of a one-dimensional chain of atoms whose spacing is given by a probability distribution function, is reduced to the form of an integral equation. This equation simplifies considerably when the atoms are distributed at random. In this case, an explicit solution for the integrated density of states is found, which is rigorously valid for $\delta$-function atomic potentials, and may be valid generally. It is shown that the solution gives good agreement with the machine results of Lax and Phillips (1958) for the $\delta$-function case.

**On the inversion temperature function of the first order (one phonon) scattering and the determination of Debye characteristic temperatures.** By M. L. Canut and J. L. Amorós.

Starting from Laval's expression for the first order thermal diffuse scattering ($TDS_1$), a new expression for the inversion temperature of $TDS_1$, $T_{max} = m\,\Theta_D^2\, d^2hkl\; k/3h^2$ has been obtained, valid for a crystal of any symmetry. $T_{max}$ is attained when $\sqrt{u^2}/dhkl = 16\%$. Every crystalline substance has a definite range where the above formula holds : The upper limit is $T_{mp}$ and the lower limit is $\Theta_D$. The melting temperature defines a $d_{max}$ for which the inversion phenomenon can be observable. The inversion curves of $TDS_1$ have been calculated for some metallic, ionic and molecular crystals. It is shown that KCl, Pb and Al, for which the inversion phenomenon has been reported, are not special cases. In molecular crystal this effect will be observable mainly at low temperatures. A method is given for determining Debye characteristic temperatures of crystals of any symmetry. This method is tested using Cartz's experimental $T_{max}$ for lead.

**Ultra-violet extensions of the arc spectra of the alkaline earths : the absorption spectrum of magnesium vapour.** By K. Codling.

The principal series of magnesium has been photographed, in absorption, in the ultra-violet region between 2400Å and 1600Å by means of a 3-metre vacuum spectrograph and a large King furnace. Measurement of twenty-four new members of the series against accurate copper standards leads to a revised value of 61670·6 $cm^{-1}$ for the ionization potential of Mg I, and increase of 1·5 $cm^{-1}$ on the value previously accepted.

**Stationary properties of the Hartree-Fock approximation.** By M. Cohen and A. Dalgarno.

The theorem is proved that the first order correction to the expectation value of any operator which can be expressed as a sum of one-electron operators vanishes if Hartree-Fock wave functions are used in its evaluation.

**Stereospecific polymers and Markoff chains.** By T. B. Grimley.

If the only factors restricting the configurations of a polymer molecule are the constancy of the C-C-C bond angle, and the existence of a potential hindering free rotation about C-C bonds, stereospecific polymers of the type $(CHX)_N$ are simple Markoff chains but the stereospecific vinyl polymers $(CH_2CHX)_N$ are not. These vinyl polymers are examples of Markoff chains with a periodic transition probability. The eigenvalue theory of such chains is briefly discussed.

**Comparison of reflection methods for measuring optical constants without polarimetric analysis, and proposal for new methods based on the Brewster angle.** By S. P. F. Humphreys-Owen.

The pairs of observations at non-normal incidence which specify the various reflection methods of determining the optical constants $n$ and $k$ are compared as to their arithmetical sensitivity to changes in $n$ and $k$ and hence as to their theoretical suitability. Only the simple methods which do not require polarimetric analysis are considered. The comparison of sensitivity is done by inspection of charts prepared from computed tables and which cover a wide range of $n$ and $k$. A previously unnoticed property of the Fresnel equations at 45° incidence allows any method, not just one in which a ratio of reflectivities is measured, to be employed without a standard reflector. Experimental factors as well as theoretical sensitivity are considered, and the use of the Brewster angle as one observation is proposed. An exact analysis of the Brewster condition has been done, which leads to explicit equations applicable to two proposed methods. The distinction between the Brewster angle and the principal angle of incidence, which are often confused, is emphasized.

**P-wave pion-pion resonance.** By A. N. Kamal.

A new phenomenological coupling constant in the pion-pion interaction is introduced through an interaction lagrangian of the form

$$\alpha_{int} = \lambda_1\, (\varphi \times \varphi_{,t})\, .\, (\varphi \times \varphi^{,t})$$

It is found that this type of interaction leads to a P-wave pion-pion resonance when summation is made over the " chain-diagrams ". The width of the resonance is adjusted by a cut-off and $\lambda_1$ is determined by the position of the resonance and the cut-off.

**The emission of charged particles from the bombardment of silver with nitrogen ions.** By J. S. Lilley.

A silver foil of 4·4 mg. $cm^{-2}$ was bombarded with the internal $^{14}_{7}N^{6+}$ beam from the 150 cm Birmingham cyclotron, and the reaction products were recorded in C2 emulsion. The energy and angular distributions of the emitted protons and α-particles were measured and the results at large angles have been compared with the predictions of evaporation theory. Good agreement was obtained by assuming that the Coulomb barrier is reduced at high nuclear excitations.
The presence of competing direct processes is discussed briefly.

**Elastic scattering of slow electrons by helium atoms.** By B. L. Moiseiwitsch.

The scattering length for elastic collisions between electrons and helium atoms is calculated with full allowance for distortion and exhange by the exact numerical integration of the appropriate integro-differential equation for the zero-order partial wave. The resulting cross section, $26q_e$, for electrons of zero impact energy is in good agreement with the available experimental data, so that the effect of polarization which is neglected in the present claculation is probably small.

**On the theory of spin-lattice relaxation in paramagnetic salts.** By R. Orbach.

A spin-Hamiltonian approach to the theory of spin-lattice relaxation in paramagnetic salts is developed in which the orbit-lattice interaction is treated as a perturbation connecting states of the overall spin Hamiltonian. The approach is much simpler than previous treatments where the spin-orbit and Zeeman effects were treated as perturbations, and is applicable to a wide range of salts including both the iron group and the rare earth group.
It is found that, for Kramers salts (ions with an odd number of electrons), many previous results apply quite generally, regardless of the relative size of the spin-orbit and crystalline field terms, but there are important exceptions. For the case of large crystalline field splittings, the relaxation rate (inverse of the relaxation time $T_1$) varies as $H^4T$ and $T^9$ for direct and Raman processes respectively, as Van Vleck has previously shown. The so-called Van Vleck cancellation leading to these dependences is derived in a very simple and quite general manner. For small crystal field splittings Δ, less than or of the order of the lattice Debye temperature, the relaxation rate varies as $H^4T$ and $[a\,\exp(-\Delta/kT) \times bT^7]$ for direct and Raman processes respectively. The two coefficients a and b are such that the $T^7$ term is important only at low temperatures where the exponential term is quite small. These results are in marked contrast with earlier theories.

**Diffraction of light by very high frequency ultrasonic waves.** By B. Ramachandra Rao and J. S. Murty.

This paper embodies the results of the investigation on diffraction of light by very high frequency ultrasonic waves in the range of 50 to 230 Mc/s. Intensity measurements were made by using a highly sensitive photomultiplier photometer. Results of the variation of the intensity of the first order of the diffraction pattern with the tilt angle for weak sound field agreed equally well with both the theories of David, and Bhatia and Noble. Measurement of intensity variation of the first order with length of the sound field at the Bragg incidence angle showed that only the theory of Bhatia and Noble is valid for stronger sound fields.

**Fluorescence and other yields of the $L_{II}$ shell in Pu.** By Lidia Salgueiro, J. Gomes Ferreira, J. J. H. Park and M. A. S. Ross.

A study has been made of the L x-radiations emitted after the disintegration of $^{242}Cm$ to determine, as accurately as possible, the fluorescence and other yields of the $L_{II}$ sub-shell in Pu. The experimental results are: $\omega_2 = 0{\cdot}413 \pm 0{\cdot}02$, $f_{23} = 0{\cdot}22 \pm 0{\cdot}08$, $a_2 = 0{\cdot}37 \pm 0{\cdot}08$. The total fluorescence yield of the L shells is $\bar{\omega} = 0{\cdot}486 \pm 0{\cdot}01$. The values of $\omega^2$ and $\bar{\omega}$ are independent of previous work on fluorescence yields, but for the distribution of yields between $f_{23}$ and $a_2$ it was necessary to use an extrapolated value of $\omega_3$.

**Application of the Schwinger variational method to zero energy electron-hydrogen scattering.** By H. E. Saraph.

The problem is formulated in terms of the radial exchange equations. The Schwinger method, with polynomial trial functions, is used to calculate the scattering length. With 3-term polynomials one obtains $A^+ = -9{\cdot}72$, $A^- = -2{\cdot}35$ compared with $A^+ = -8{\cdot}095$, $A^- = -2{\cdot}350$ from exact numerical integrations.

**The variation of the fracture energy of brittle plastics with temperature.** By N. L. Svensson.

A method for the determination of the fracture energy of brittle plastics is described. A crack is propagated down the length of a rectangular specimen under controlled conditions and the variation of crack opening with length determined. From these results the fracture energy may be calculated. The method has been applied to determine the variation of fracture energy for polymethyl-methacrylate and polystyrene with temperature in the range 20°C to 80°C. The results of tests carried out at room temperature show good agreement with similar results obtained by other investigators.

**Negative oxygen ions from a glow discharge source.** By W. S. Whitlock and J. E. Bounden.

A simple source of $O^-$ ions suitable for accelerator applications is described. Negative atomic ion currents of over 2 μA can be directly extracted at 10 keV energy from a low-pressure cold-cathode oxygen discharge source which incorporates an electrostatic constrictor electrode. The input power is only 25 watts and the gas consumption 14 $cm^3$ $hour^{-1}$ of oxygen at atmospheric pressure.

Mass analysis of the beam has shown the primary components to be $O^-$ and $O_2^-$ ions whilst the main impurity ions are $OH^-$, $Cl^-$ and $NO_2^-$.

A study has been made of the relationship between the negative ion yield and various source operating conditions. The $O^-$ and $O_2^-$ ion yields are shown to be related to the striated structure of the positive column. With a singly striated column the beam is composed mainly of atomic ions. Only when a doubly striated column is formed does the $O_2^-$ yield become large. Ion production processes are discussed in terms of this relationship.

**The ohmic heating of positive ions in an impure plasma.** By A. A. Ware and J. A. Wesson.

It is shown that in a plasma which is heated by an electric current the direct heating of the positive ions can be increased markedly by the presence of a small concentration of impurity ions. With favourable impurity concentrations, this heating is sufficient to explain the observed ion temperature in Zeta and Sceptre.

**Electrical and optical properties of GaAs-InAs alloys.** By J. C. Woolley, C. M. Gillett and J. A. Evans.

Solid specimens of GaAs-InAs alloys, showing a composition spread of less than 3 Mol.%, have been prepared by a slow directional freeze technique. These specimens have been used for measurements of Hall effect and conductivity as a function of temperature and for infra-red transmission measurements to determine the optical energy gap. The electrical measurements show the alloys to be compensated and hence the values of Hall mobility have no significance. The optical measurements to determine the variation of $E_g$ with composition are in good agreement with values obtained by diffuse reflection methods on single phase powder samples. The values of $E_G$ show a linear variation over most of the composition range.

**The reduced equation of state of the inert gas solids at the absolute zero.** By I. J. Zucker.

It is shown that a law of corresponding states exists amongst the inert gases in the solid phase even when quantum effects are large. The theoretical treatment is based on the Einstein model of a crystal modified to account for large vibrations on the crystal atoms. Using a Lennard-Jones 12-6 potential for the interaction energy between a pair of atoms, reasonable agreement is obtained between theoretical and experimental values for the equilibrium volumes and energies of the rare gas crystals at the absolute zero.

*Amendment*

In the November *Bulletin* the wrong abstract was printed for the paper entitled **The thermomagnetic behaviour of cobalt ferrite.** By L. F. Bates and A. J. Pacey. The correct abstract is as follows:—

The small heat changes accompanying the magnetization of cobalt ferrite were measured with two rod specimens. One had been heat-treated to destroy uniaxial anisotropy, the other was untreated. A new method of analysis of the results is described, and while its application to these specimens may not have led to conclusive results, it appears to give useful information when applied to materials of less complex magnetic behaviour.

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## LETTER TO THE EDITOR

**On the validity of two conjectures relating to resonance collisions.** By B. G. Skinner.

COMMONWEALTH OF AUSTRALIA

WEAPONS RESEARCH ESTABLISHMENT

## Ionospheric Physics

*The Department of Supply invite applications for the following vacant position at the Weapons Research Establishment, Salisbury, near Adelaide:—*

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**APPLICATIONS:** Forms obtainable from the Senior Representative (AV.91/7), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged as soon as possible.

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## RESEARCH STAFF

### (Several Positions)

The Organization's Division of Textile Industry, Geelong, Victoria, of the Wool Research Laboratories is concerned broadly with development of new physical and chemical techniques in wool textile processing. Well equipped laboratories for fundamental studies and full scale mill equipment for the application of results are available. Current research includes absorption studies on wool; fibre friction; permanent setting; shrinkage prevention; mechanical action of machines on wool fibres; servo-control mechanisms in processing; development of new machines.

Applications are invited from Honours graduates in Science or Engineering with some years' postgraduate research experience for research in the following fields:—

1. Chemical studies on modification of wool fibres which involves the study of reactions with a view to developing new fabric finishes;
2. The development of new physical methods for separating vegetable material from wool;
3. Physical studies on fibre friction, and the effects of lubricants;
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Fares paid. Further details of conditions, etc., supplied on application to:—

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 464/221) should be addressed by **January 28, 1961.**

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**Department of Electrical Engineering and Physics**

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Salary in accordance with the Burnham technical scale; men: £1,370 × £35–£1,550 per annum; until April 1, 1961, the scale for women is slightly lower.

Further particulars and form of application, to be returned as soon as possible, may be obtained by sending a stamped addressed foolscap envelope to the Principal of the College.

**George Taylor,**
Chief Education Officer.
Education Department,
**Leeds, 1.**

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UNIVERSITY OF READING. Applications are invited for a LECTURESHIP in AGRICULTURAL ENGINEERING from persons with qualifications in electrical engineering or electronics with an interest in the application to agricultural operations of electronic and other control methods. Further particulars may be obtained from the Registrar (Room 22, O.R.B.), The University, Reading, to whom applications should be sent not later than January 21, 1961.

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